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Medical **nanorobot** architecture based on nanobioelectronics [PDF] from psu.edu
A Cavalcanti, B Shirinzadeh… - Recent **Patents** on …, 2007 - ingentaconnect.com
Received: December 8, 2006; Accepted: December 14, 2006; Revised: December 15, 2006
Abstract: This work describes an innovative medical **nanorobot** architecture based on important discoveries in nanotechnology, integrated circuit **patents**, and some publications, directly **…**
Cited by 15 - Related articles - BL Direct - All 11 versions

Nanorobot architecture for medical target identification
A Cavalcanti, B Shirinzadeh, RA Freitas Jr… - …, 2008 - iopscience.iop.org
… from light is another option for energy generation in determined open environments [95] but not for in vivo medical **nanorobotics**. Kinetic energy can be generated from the bloodstream due to motion interaction with designed devices embedded with the **nanorobot** [96], but this **…**
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System, methods and apparatuses for integrated circuits for **nanorobotics**
N Solomon - US **Patent** App. 20,080/244,500, 2007 - freepatentsonline.com
… For the most part, these **patents** represent third and fourth generation nanotechnologies. **…** The chips are applied to **nanorobotics**. By integrating nano-scale ICs into nanorobots, the **nanorobot** devices obtain intelligence functionality that includes data analysis, memory access **…**
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Medical **nanorobotics** for diabetes control
A Cavalcanti, B Shirinzadeh… - … : Nanotechnology, Biology and …, 2008 - Elsevier
… photonics. To illustrate the **nanorobot** integrated circuit architecture and layout described here, a computational approach with the application of medical **nanorobotics** for diabetes is simulated using clinical data. Integrated simulation **…**
Cited by 6 - Related articles - BL Direct - All 4 versions

[PDF] **Nanorobotics** Control Design for Nanomedicine [PDF] from cannxs.org
A Cavalcanti - 2009 - cannxs.org
… com/y2008/0241264.html 60 N. Solomon, "System and methods for collective **nanorobotics** for electronics **…** 0849321239 14 GM Patel, GC Patel, RB Patel, JK Patel, M. Patel, "**Nanorobot**: A versatile **…** W. Xu, Z.-Z. Zhang, L. He, "Research and progress in bio-**nano**- **robot**", Robot, Vol **…**
Cited by 1 - Related articles - View as HTML

NANOROBOTICS SYSTEM
N SOLOMON - WO **Patent** WO/2008/063,473, 2008 - wipo.int
… Priority Data: 60/865,605, 13.11.2006, US. 60/912,133, 16.04.2007, US. Title: **NANOROBOTICS** SYSTEM. **…** African Regional Intellectual Property Org. (ARIPO) (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW) Eurasian **Patent** Organization (EAPO) (AM, AZ, BY, KG, **…**
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System and methods for collective **nanorobotics** for electronics applications
N Solomon - US **Patent** App. 20,080/243,303, 2007 - freepatentsonline.com
… For the most part, these **patents** represent third and fourth generation nanotechnologies. **…** Develop nanorobotic communication system(s); Develop multi-functional **nanorobotics**; Develop systems in **…** Develop an external tracking procedure for a **nanorobot**; Develop an external **…**
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System and methods for collective **nanorobotics** for medical applications
N Solomon - US **Patent** App. 20,080/241,264, 2007 - freepatentsonline.com
… No. 6,943,242), used for a DNA microarray, are applied to biotechnology. For the most part, these **patents** represent third and fourth generation nanotechnologies. **…** Develop multi-functional **nanorobotics**. **…** Develop an external tracking procedure for a **nanorobot**. **…**
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(EN) **NANOROBOT** MODULE AUTOMATION AND EXCHANGE
V KLOCKE - WO **Patent** WO/2008/128,532, 2008 - wipo.int
… adapter for the flexible fixing of **nanorobot** modules within a vacuum chamber, in particular an exchange adapter which preferably connects a **nanorobot** module in a **…** (ARIPO) (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW) Eurasian **Patent** Organization (EAPO **…**
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SYSTEM, METHOD, AND **NANOROBOT** TO EXPLORE SUBTERRANEAN GEOPHYSICAL FORMATIONS
R KAMAL, M SANNI… - WO **Patent** WO/2010/105,177, 2010 - wipo.int
… 12/722,357, 11.03.2010, US. Title: SYSTEM, METHOD, AND **NANOROBOT** TO EXPLORE SUBTERRANEAN GEOPHYSICAL FORMATIONS. **…** (ARIPO) (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW) Eurasian **Patent** Organization (EAPO) (AM, AZ, BY, KG, KZ, MD **…**
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A Cavalcanti, B Shirinzadeh, RA Freitas Jr... - ..., 2007 - iopscience.iop.org
... 3. Medical **nanorobotics** ... The **nanorobot** proposed prototyping must be equipped with the necessary devices for monitoring the most important ... with 3D simulation should facilitate the **manufacturing** design of nanorobots with integrated embedded nanoelectronics and **circuits**. ...
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Nanorobot hardware architecture for medical defense — mdpi.com [PDF]
A Cavalcanti, B Shirinzadeh, M Zhang, LC Kretly - Sensors, 2008 - mdpi.com
... faster rates of data transmission, its energy demand makes it not ideal for medical **nanorobotics** [92 ... Works with RFID have been developed as an integrated **circuit** device for medicine [70 ... Thus, the **nanorobot** should be equipped with single-chip RFID CMOS based sensors [65,93 ...
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Medical **nanorobot** architecture based on nanobioelectronics — nanorobotdesign.com [PDF]
A Cavalcanti, B Shirinzadeh... - Recent Patents on ..., 2007 - ingentaconnect.com
... **Circuit** design approaches to solve problems with bipolar effect and hysteretic variations based on ... determined open workspaces [65] but not for in vivo medical **nanorobotics**, especially since ... due to motion interaction with designed devices embedded with the **nanorobot** [66], but ...
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Computational nanomechatronics: A pathway for control and **manufacturing** nanorobots
A Cavalcanti, WW Wood, LC Kretly... - ... for Modelling, Control ..., 2006 - ieeexplore.ieee.org
... on Solid-State and Integrated **Circuits** Technology, vol. 1, pp. ... [16] WJ Li, N. Xi, WK Fung, TS Wong, "**Nanorobotics** and Nanomanipulation", Encyclopedia of Nanoscience and Nanotechnology, American Scientific Publishers, vol. ... [18] JS MacNeil, "**Nanorobot** Pioneer Reveal ...
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Hardware architecture for **nanorobot** application in cerebral aneurysm — nanorobotdesign.com [PDF]
A Cavalcanti, B Shirinzadeh, T Fukuda... - ... , 2007. IEEE-NANO ..., 2007 - ieeexplore.ieee.org
Hardware Architecture for **Nanorobot** Application in Cerebral ... Keywords — Architecture, CMOS integrated **circuits**, DNA molecular machine, medical **nanorobotics**, nanobioelectronics ... to benefit from current research and developments in the field medical **nanorobotics** [1]. The ...
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Medical **nanorobotics** for diabetes control
A Cavalcanti, B Shirinzadeh, LC Kretly - ... : Nanotechnology, Biology and ..., 2008 - Elsevier
... To illustrate the **nanorobot** integrated **circuit** architecture and layout described here, a computational approach with the application of medical **nanorobotics** for diabetes ... Integrated simulation can provide interactive tools for addressing **nanorobot** choices on sensing, hardware ...
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Nanorobots for laparoscopic cancer surgery — nanorobotdesign.com [PDF]
A Cavalcanti, B Shirinzadeh, D Murphy... - ... Science, 2007. ICIS ..., 2007 - ieeexplore.ieee.org
... Keywords: Architecture, cancer, hardware, integrated **circuit**, medical **nanorobotics**, nanobioelectronics, nanomechatronics ... The main parameters used for the medical **nanorobot** architecture for ... the most common methodology utilized in the integrated **circuit** (IC) **manufacturing** ...
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[PDF] Hardware Architecture for **Nanorobot** Application in Cancer Therapy — nanorobotdesign.com [PDF]
A Cavalcanti, B Shirinzadeh, T Hogg... - IEEE-RAS ICAR Intl. ..., 2007 - nanorobotdesign.com
... machine, E-cadherin signal, electromagnetic coupling, medical **nanorobotics**, nanobioelectronics, nanomechatronics ... The main parameters used for the medical **nanorobot** architecture and ... the most common methodology utilized in the integrated **circuit manufacturing** industry [20 ...
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Nanorobot for brain aneurysm
A Cavalcanti, B Shirinzadeh, T Fukuda... - ... International Journal of ..., 2009 - ijr.sagepub.com
... is also not used in nanoelectronics **manufacturing**, which inte- grates the current methodology in use towards the commer- cialization of high-performance nano-integrated **circuits** (ICs). ... The present **nanorobot** archi- tecture provides a medical **nanorobotics** model in ...
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System, methods and apparatuses for integrated **circuits** for **nanorobotics**
N Solomon - US Patent 7,921,384, 2011 - Google Patents
... SUMMARY OF THE INVENTION The invention specifies nano-scale integrated **circuits** (ICs) 35 with applications to ... The chips are applied to **nanorobotics**. By integrating nano- scale ICs into nanorobots, the **nanorobot** devices obtain intel- 50 ligence functionality that includes ...
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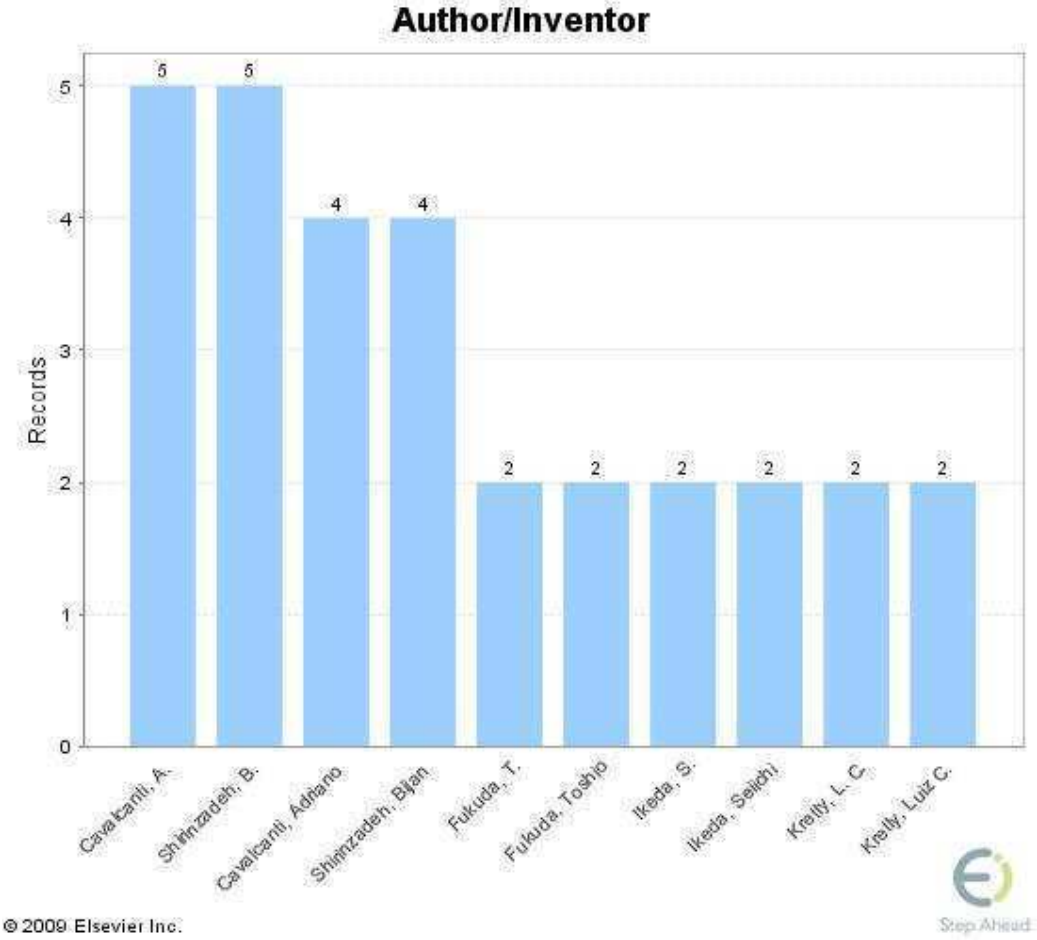

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Record 8 from Inspec for: ((nanomechatronics) WN KY), 1785-2009

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8.

Accession number: 10208174

Title: Computational nanomechatronics: a pathway for control and manufacturing nanorobots

Authors: Cavalcanti, A.[1] ; Wood, W.W.; Kretly, L.C.; Shirinzadeh, B.

Author affiliation: [1] Dept. of Mech. Eng., Monash Univ., Melbourne, VIC, Australia

Source: 2006 International Conference on Computational Intelligence for Modelling Control and Automation and International Conference on Intelligent Agents Web Technologies and International Commerce (CIMCA'06)

Publication date: 2006

Pages: 6 pp.

Language: English

ISBN-10: 0-7695-2731-0

Document type: Conference article (CA)

Conference name: 2006 International Conference on Computational Inteligence for Modelling Control and Automation and International Conference on Intelligent Agents Web Technologies and International Commerce (CIMCA'06)

Conference date: 29 Nov.-1 Dec. 2006

Conference location: Sydney, NSW, Australia

Publisher: IEEE

Place of publication: Piscataway, NJ, USA

Material Identity Number: YXA8-1901-844

Abstract: This paper describes an innovative work for nanorobot design and manufacturing, using a computer simulation and system on chip prototyping approach. The use of CMOS as integrated circuits, with the miniaturization from micro towards nanoelectronics, and the respective advances of nanowires are considered into the proposed model design and discussed as a practical pathway to enable embedded sensors for manufacturing nanorobots. The proposed nanorobot model is applied to hydrology monitoring. It can be useful for agriculture or environmental monitoring and management.

Number of references: 38

Inspec controlled terms: agriculture - CMOS integrated circuits - control system CAD - environmental management - hydrology - intelligent sensors - mechatronics - microrobots - nanoelectronics - nanowires - system-on-chip

Uncontrolled terms: computational nanomechatronics - nanorobot control - nanorobot manufacturing - nanorobot design - computer simulation - system on chip prototyping approach - CMOS - integrated circuits - nanoelectronics - nanowires - embedded sensors - hydrology monitoring - agriculture - environmental monitoring

Inspec classification codes: C3390 Robotics - C7420D Control system design and analysis - C3310C Control applications in agriculture - C3240N Intelligent sensors

Treatment: Practical (PRA)

Discipline: Computers/Control engineering (C)

Database: Inspec

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1.
Title: Medical nanorobotics for diabetes control
Author(s): Cavalcanti, Adriano; Shirinzadeh, Bijan; Kretly, Luiz C.
Source: NANOMEDICINE-NANOTECHNOLOGY BIOLOGY AND MEDICINE
Volume: 4
Issue: 2
Pages: 127-138
DOI: 10.1016/j.nano.2008.03.001
Published: JUN 2008
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16.

Accession number: 9864214

Title: Nanorobots for laparoscopic cancer surgery

Authors: Cavalcanti, A.[1] ; Shirinzadeh, B.[1] ; Murphy, D.; Smith, J.A.

Author affiliation: [1] Monash Univ., Clayton, Australia

Source: 2007 International Conference on Computer and Information Science

Publication date: 2007

Pages: 715-20

Language: English

ISBN-10: 0-7695-2841-4

Document type: Conference article (CA)

Conference name: 2007 International Conference on Computer and Information Science

Conference date: 11-13 July 2007

Conference location: Melbourne, Qld., Australia

Publisher: IEEE

Place of publication: Piscataway, NJ, USA

Material Identity Number: YXA8-1900-483

Abstract: This paper presents an innovative hardware architecture for medical nanorobots, using nanobioelectronics, clinical data, and wireless technologies, as embedded integrated system devices for molecular machine data transmission and control upload, and show how to use it in cancer surgery. The integration of medical nanorobotics and surgical teleoperation has the use of robotic laparoscopy concepts. To illustrate the proposed approach, we applied advanced 3D simulation techniques as a practical choice on methodology for molecular machine integrated system analyses and biomedical instrumentation prototyping.

Number of references: 29

Inspec controlled terms: medical robotics - nanoelectronics - telerobotics

Uncontrolled terms: laparoscopic cancer surgery - innovative hardware architecture - medical nanorobots - nanobioelectronics - clinical data - wireless technologies - embedded integrated system devices - molecular machine data transmission - surgical teleoperation - 3D simulation techniques

Inspec classification codes: C3385 Biological and medical control systems - C3390T Telerobotics

Treatment: Practical (PRA)

Discipline: Computers/Control engineering (C)

Database: Inspec

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1 **Medical nanorobotics for diabetes control** Original Research Article

Nanomedicine: Nanotechnology, Biology and Medicine, Volume 4, Issue 2, June 2008, Pages 127-138

Adriano Cavalcanti, Bijan Shirinzadeh, Luiz C. Kretly

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2.

Accession number: 9958588

Title: Nanorobot architecture for medical target identification

Authors: Cavalcanti, A.[1] ; Shirinzadeh, B.; Freitas, R.A., Jnr; Hogg, T.

Author affiliation: 1 CAN Center for Autom. in Nanobiotech., Melbourne, VIC, Australia

Source title: Nanotechnology

Abbreviated source title: Nanotechnol. (UK)

Volume: 19

Issue: 1

Publication date: 9 Jan. 2008

Pages: 015103-1-15

Language: English

ISSN: 0957-4484

CODEN: NNOTER

Document type: Journal article (JA)

Publisher: IOP Publishing Ltd.

Country of publication: UK

Material Identity Number: ET07-2008-012

Abstract: This work has an innovative approach for the development of nanorobots with sensors for medicine. The nanorobots operate in a virtual environment comparing random, thermal and chemical control techniques. The nanorobot architecture model has nanobioelectronics as the basis for manufacturing integrated system devices with embedded nanobiosensors and actuators, which facilitates its application for medical target identification and drug delivery. The nanorobot interaction with the described workspace shows how time actuation is improved based on sensor capabilities. Therefore, our work addresses the control and the architecture design for developing practical molecular machines. Advances in nanotechnology are enabling manufacturing nanosensors and actuators through nanobioelectronics and biologically inspired devices. Analysis of integrated system modeling is one important aspect for supporting nanotechnology in the fast development towards one of the most challenging new fields of science: molecular machines. The use of 3D simulation can provide interactive tools for addressing nanorobot choices on sensing, hardware architecture design, manufacturing approaches, and control methodology investigation.

Number of references: 129

Inspec controlled terms: biomedical electronics - biomolecular electronics - DNA - drug delivery systems - medical robotics - microsensors - molecular biophysics - nanobiotechnology - nanoelectronics

Uncontrolled terms: nanorobot - medical target identification - medicine - virtual environment - nanobioelectronics - integrated system devices - nanobiosensors - actuators - nanosensors - drug delivery - nanorobot interaction - nanotechnology - biologically inspired devices - DNA molecular machine

Inspec classification codes: A8783 Nanotechnology applications in biomedicine - A8770G Patient care and treatment - A8715 Molecular biophysics - B2230B Biomolecular electronics - B7520 Patient care and treatment - B7230M Microsensors - C3385 Biological and medical control systems - C3390C Mobile robots - C3240P Microsensors

Treatment: Practical (PRA)

Discipline: Physics (A); Electrical/Electronic engineering (B); Computers/Control engineering (C)

DOI: 10.1088/0957-4484/19/01/015103

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From: 2002

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AUTHOR

- Cavalcanti, A. (5)
- Shirinzadeh, B. (2)
- Einav, S. (1)
- Fukuda, T. (1)
- Ikeda, S. (1)
- Kretly, L.C. (1)
- Hogg, T. (1)
- Rosenfeld, M. (1)
- Curtis, A.S.G. (1)
- Rosen, L. (1)

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- Centre for Cell Eng., Glasgow Univ., UK (1)
- Electr. & Comput. Eng. Sch., Campinas, Brazil (1)
- Dept. of Mech. Eng., Monash Univ., Clayton, VIC (1)

PUBLICATION TITLE

- Nanotechnology, IEEE Transactions on (1)
- Nanotechnology, 2002. IEEE-NANO 2002. Proceedings of

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Assembly automation with evolutionary nanorobots and sensor-based control applied to nanomedicine

Cavalcanti, A.
Nanotechnology, 2002. IEEE-NANO 2002. Proceedings of the 2002 2nd IEEE Conference on
Digital Object Identifier: 10.1109/NANO.2002.1032215
Publication Year: 2002 , Page(s): 161 - 164
IEEE CONFERENCE PUBLICATIONS

Quick Abstract | PDF (415 KB)

The author presents a new approach within advanced graphics simulations for the problem of nanoassembly automation and its application for medicine. The problem under study concentrates its main focus on nanorobot autonomous control for assembly manipulation and the use of evolutionary competitive agents as a suitable way to warranty the robustness of any proposed model. Thereby the presented paper summarizes as well distinct aspects of some techniques required to achieve a successful nanoplanning system design and its simulation visualization in real time. View full abstract»

Hardware architecture for nanorobot application in cerebral aneurysm

Cavalcanti, A.; Shirinzadeh, B.; Fukuda, T.; Ikeda, S.
Nanotechnology, 2007. IEEE-NANO 2007. 7th IEEE Conference on
Digital Object Identifier: 10.1109/NANO.2007.4601179
Publication Year: 2007 , Page(s): 237 - 242
IEEE CONFERENCE PUBLICATIONS

Quick Abstract | PDF (342 KB)

This paper presents an innovative hardware architecture for medical use of nanorobots proposed as an advanced and precise tool for brain aneurysm instrumentation and diagnosis. The feasibility of the outlined architecture is supported by nanobioelectronics, clinical data, and wireless technologies, as embedded integrated system devices for molecular machine data transmission and control upload. The upcoming therapeutic possibility of using nanorobots for aneurysm treatments is the natural result from some recent developments and trends in nanoelectronics, wireless communication, remote power transmission, quantum dots, nanotubes, SOI, lithography, biomedical instrumentation, genome mapping, and photonics. To illustrate the proposed

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- Nanotechnology, 2007. IEEE-NANO 2007. 7th IEEE Conference on (1)

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approach, we applied advanced 3D simulation techniques as a practical choice on methodology for medical nanorobotics architecture and integrated system prototyping. View full abstract»

Nanorobotics System Simulation in 3D Workspaces with Low Reynolds Number

Cavalcanti, A.; Hogg, T.; Shirinzadeh, B.
Micro-NanoMechatronics and Human Science, 2006 International Symposium on
Digital Object Identifier: 10.1109/MHS.2006.320269
Publication Year: 2006 , Page(s): 1 - 6
IEEE CONFERENCE PUBLICATIONS

Quick Abstract | PDF (7465 KB)

We present a computational approach to enable the development of nanorobots operating in a fluid environment relevant for medical applications. Unlike the case of larger robots, the dominant forces in this environment arise from viscosity of low Reynolds number fluid flow and Brownian motion and such parameters are described throughout the paper. Hence, this paper describes a practical simulator that allows fast design methodology comparing various control algorithms for nanorobots and their suitability for different tasks. The simulator includes obstacles and identifiable targets, thereby providing a suitable environment for a typical nanorobot task: maintaining desired chemical concentrations near specific target areas View full abstract»

Nanorobotic challenges in biomedical applications, design and control

Cavalcanti, A.; Rosen, L.; Kretly, L.C.; Rosenfeld, M.; Einav, S.
Electronics, Circuits and Systems, 2004. ICECS 2004. Proceedings of the 2004 11th IEEE International Conference on
Digital Object Identifier: 10.1109/ICECS.2004.1399714
Publication Year: 2004 , Page(s): 447 - 450
IEEE CONFERENCE PUBLICATIONS

Quick Abstract | PDF (651 KB)

Ongoing developments in molecular fabrication, computation, sensors and motors will enable the manufacturing of nanorobots - nanoscale biomolecular machine systems. The present work constitutes a novel simulation approach, intended to be a platform for the design and research of nanorobot control. The simulation approach involves a combined and multi-scale view of the scenario. Fluid dynamics numerical simulation is used to construct the nanorobotic environment, and an additional simulation models nanorobot sensing, control and behavior. We discuss some of the most promising possibilities for nanorobotics applications in biomedical problems, paying a special attention to a stenosed coronary artery case. View full abstract»

Assembly automation with evolutionary nanorobots and sensor-based control applied to nanomedicine

Cavalcanti, A.
Nanotechnology, IEEE Transactions on
Volume: 2 , Issue: 2
Digital Object Identifier: 10.1109/TNANO.2003.812590
Publication Year: 2003 , Page(s): 82 - 87
Cited by: 21
IEEE JOURNALS & MAGAZINES

Quick Abstract | PDF (1035 KB)

The author presents a new approach within advanced graphics simulations for the problem of nano-assembly automation and its application for medicine. The problem under study concentrates its main focus on nanorobot control design for assembly manipulation and the use of evolutionary competitive agents as a suitable way to warranty the robustness on the proposed model.

Thereby the presented paper summarizes as well distinct aspects of some techniques required to achieve a successful nano-planning system design and its simulation visualization in real time. View full abstract»

Comment on "Nanorobotics control design: a collective behavior approach for medicine"

Curtis, A.S.G.

NanoBioscience, IEEE Transactions on

Volume: 4 , Issue: 2

Digital Object Identifier: 10.1109/TNB.2005.850470

Publication Year: 2005 , Page(s): 202 - 203

IEEE JOURNALS & MAGAZINES

Quick Abstract | PDF (41 KB)

Following the paper by Calcavani and Freitas (see ibid., vol.4, no.2, p.133-40, 2005), the limitations on nanorobot design and activity imposed by Brownian motion events, communication problems, and the nature of the intercellular space are discussed. It is shown that severe problems exist for a nanorobot designed to enter tissues for therapeutic purposes when it is smaller than about 1 μm in any one of its dimensions.

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Author(s): Cavalcanti A, Shirinzadeh B, Fukuda T, et al.
Source: **INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH** Volume: **28** Issue: **4** Pages: **558-570** Published: **APR 2009**
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Author(s): Cavalcanti A, Shirinzadeh B, Kretly LC
Source: **NANOMEDICINE-NANOTECHNOLOGY BIOLOGY AND MEDICINE** Volume: **4** Issue: **2** Pages: **127-138** Published: **JUN 2008**
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3. Title: Hardware Architecture for Nanorobot Application in Cerebral Aneurysm
Author(s): Cavalcanti A, Shirinzadeh B, Fukuda T, et al.
Conference Information: 7th IEEE Conference on Nanotechnology, AUG 02-05, 2007 Hong Kong, PEOPLES R CHINA
Source: **2007 7TH IEEE CONFERENCE ON NANOTECHNOLOGY, VOL 1-3** Pages: **237-242** Published: **2007**
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4. Title: Nanorobot hardware architecture for medical defense
Author(s): Cavalcanti A, Shirinzadeh B, Zhang MJ, et al.
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3.

Accession number: 7669617

Title: Assembly automation with evolutionary nanorobots and sensor-based control applied to nanomedicine

Authors: Cavalcanti, A.[1]

Author affiliation: [1] Fraunhofer Inst. for Comput. Graphics, Darmstadt, Germany

Source title: IEEE Transactions on Nanotechnology

Abbreviated source title: IEEE Trans. Nanotechnol. (USA)

Volume: 2

Issue: 2

Publication date: June 2003

Pages: 82-7

Language: English

ISSN: 1536-125X

CODEN: ITNECU

Document type: Journal article (JA)

Publisher: IEEE

Country of publication: USA

Material Identity Number: N761-2003-004

Abstract: The author presents a new approach within advanced graphics simulations for the problem of nano-assembly automation and its application for medicine. The problem under study concentrates its main focus on nanorobot control design for assembly manipulation and the use of evolutionary competitive agents as a suitable way to warranty the robustness on the proposed model. Thereby the presented paper summarizes as well distinct aspects of some techniques required to achieve a successful nano-planning system design and its simulation visualization in real time

Number of references: 28

Inspec controlled terms: assembly planning - biomedical engineering - evolutionary computation - microrobots

Uncontrolled terms: assembly automation - evolutionary nanorobots - sensor-based control - nanomedicine - advanced graphics simulations - nano-assembly automation - nanorobot control design - evolutionary competitive agents - robustness - nano-planning system design - simulation visualization

Inspec classification codes: A8770J Prosthetics and other practical applications - A0710C Micromechanical devices and systems - C3385 Biological and medical control systems - C3390 Robotics - C7420 Control engineering computing - C3260P Microactuators - C7330 Biology and medical computing - C3355F Control applications in assembling - E0410D Industrial applications of IT - E1520C Assembling - E1550 Control technology and theory - E1550A Robotics - E1640 Instrumentation - E3654 Medical equipment and supplies industry

Treatment: Applications (APP); Practical (PRA); Experimental (EXP)

Discipline: Physics (A); Computers/Control engineering (C); Manufacturing and production engineering (E)

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1. **Computational nanomechatronics: a pathway for control and manufacturing nanorobots**

Cavalcanti, A. (Dept. of Mech. Eng., Monash Univ., Melbourne, VIC, Australia); Wood, W.W.; Kretly, L.C.; Shirinzadeh, B. **Source:** *2006 International Conference on Computational Intelligence for Modelling Control and Automation and International Conference on Intelligent Agents Web Technologies and International Commerce (CIMCA'06)*, p 6 pp., 2006

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2. **Hardware architecture for nanorobot application in cerebral aneurysm**

Cavalcanti, Adriano (Robotics and Mechatronics Research Lab., Dept. of Mechanical Eng., Monash University, Australia); Shirinzadeh, Bijan; Fukuda, Toshio; Ikeda, Seiichi **Source:** *2007 7th IEEE International Conference on Nanotechnology - IEEE-NANO 2007, Proceedings*, p 237-242, 2007, *2007 7th IEEE International Conference on Nanotechnology - IEEE-NANO 2007, Proceedings*

Database: Compendex

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3. **Computational nanomechatronics: A pathway for control and manufacturing nanorobots**

Cavalcanti, Adriano (Robotics and Mechatronics Research Lab., Dept. of Mechanical Eng., Monash University Clayton, Melbourne, VIC 3800, Australia); Wood, Warren W.; Kretly, Luiz C.; Shirinzadeh, Bijan **Source:** *CIMCA 2006: International Conference on Computational Intelligence for Modelling, Control and Automation, Jointly with IAWTIC 2006: International Conference on Intelligent Agents Web Technologies ...*, 2007, *CIMCA 2006: International Conference on Computational Intelligence for Modelling, Control and Automation, Jointly with IAWTIC 2006: International Conference on Intelligent Agents Web Technologies ...*

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- Ikeda, Seiichi (1)
- Kretly, L. C. (1)
- Kretly, Luiz C. (1)
- Shirinzadeh, B. (1)
- Wood, W. W. (1)
- Wood, Warren W. (1)

Author affiliation

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- Department Of Integrative Studies, Michigan State University (1)
- Dept. Of Mech. Eng., Monash Univ., Melbourne, Vic (1)
- Dept. Of Micro-Nano Systems Eng., Nagoya University (1)
- Microwave And Optics Dept., Electrical And Computer Eng. School, University Of Campinas (1)
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International Journal of Robotics Research

Nanorobot for Brain Aneurysm

Journal:	*The International Journal of Robotics Research*
Manuscript ID:	IJRR-07-0155
Manuscript Type:	Nanorobotics
Date Submitted by the Author:	09-Nov-2007
Complete List of Authors:	Cavalcanti, Adriano; CAN Center for Automation in Nanobiotech
Keyword:	Micro/Nano Robots < Mechanics, Design and Control, Mechanism Design < Mechanics, Design and Control, Virtual Reality and Interfaces < Simulation, Interfaces and Virtual Reality

Abstract: This paper describe how nanotechnology and medical robotics should advance minimally invasive treatments, providing major guidelines for teleoperated techniques and overall equipment design of nanorobots applied to common utilization in medical procedures. Hence, an innovative hardware architecture for medical nanorobots is disclosed, using nanobioelectronics, clinical data, and wireless technologies, as embedded integrated system devices for molecular machine data transmission and control upload, and show how to use it in cerebral aneurysm. The upcoming therapeutic possibility of using nanorobots for intracranial treatments is the natural result from some recent developments and trends in nanoelectronics, ubiquitous patient monitoring, remote power transmission, quantum dots, nanotubes, SoC, biomedical instrumentation, genome mapping, and photonics. To illustrate the proposed approach, the nanorobots must detect protein overexpression signals in order to recognize initial stages of aneurysm. Advanced 3D simulation is adopted as a practical choice on methodology for molecular machine integrated system analyses and biomedical instrumentation prototyping.

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System, methods and apparatuses for nanoelectronics applied to ...

www.google.com/patents/US20080237754
US Pat. App 11985078 - Filed 13 Nov 2007 - Solomon Research LLC
[0018] The problems to identify include how to: [0019] Build **nanorobots ... Cavalcanti** has developed theoretical notions to develop a model of nanorobotics.
Overview - Abstract - Drawing - Description - Claims

System and methods for collective nanorobotics for medical ...

www.google.com/patents/US20080241264
US Pat. App 11985046 - Filed 13 Nov 2007 - Solomon Research LLC
Fifth, controlling the interaction of **nanorobots** in a collective system with its **... Cavalcanti** has developed theoretical notions to develop a model of **...**
Overview - Abstract - Drawing - Description - Claims

System and methods for collective nanorobotics for electronics ...

www.google.com/patents/US20080243303
US Pat. App 11985083 - Filed 13 Nov 2007 - Solomon Research LLC
Fifth, controlling the interaction of **nanorobots** in a collective system with its **... Cavalcanti** has developed theoretical notions to develop a model of **...**
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System, methods and apparatuses for integrated circuits for ...

www.google.com/patents/US7921384
US Pat. 7921384 - Filed 13 Nov 2007 - Issued 5 Apr 2011
Cavalcanti has developed theoretical notions to develop a model of nanorobotics. **...** In addition, the structure of these **nanorobots** cannot be built **...**
Overview - Abstract - Drawing - Description - Claims

System and methods for immunocomputing applied to collectives of ...

www.google.com/patents/US20080270097
US Pat. App 11985074 - Filed 13 Nov 2007 - Solomon Research LLC
Cavalcanti has developed theoretical notions to develop a model of collective **...** autonomous computation resources of **nanorobots** are insufficient to perform **...**
Overview - Abstract - Drawing - Description - Claims

Compounds, methods, and treatments for abnormal signaling pathways ...

www.google.com/patents/US20110218176
US Pat. App 13102696 - Filed 6 May 2011
Article1D:2035; (b) Adriano **Cavalcanti**, Bijan Shirinzadeh, Tad Hogg, JulianA. Smith, “Hardware Architecture for **Nanorobot** Application in Cancer Therapy”, **...**

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NANOROBOT MODULE AUTOMATION AND EXCHANGE
V KLOCKE, 2008 - wipo.int
... Abstract: (EN) The **invention** relates to a **nanorobot** module with a measuring device for measuring spatial surface properties with a measuring in the centimetre **...**
Cached - All 2 versions

System, methods and apparatuses for **nanorobotics** and microrobotics
N Solomon, 2008 - freepatentsonline.com
... include how to: Build **nanorobots**; Connect nanodevices; **...** system(s); Develop multi-functional **nanorobotics**; **...** an external activation of a **nanorobot**; Obtain **...**

System, methods and apparatuses for nanoelectronics applied to **nanorobots**
N Solomon, 2008 - freepatentsonline.com
... Develop multi-functional **nanorobotics**; Activate **nanorobotic** functionality; **...** Develop an external activation of a **nanorobot**; **...** control system for **nanorobots**; Use AI for **...**

[BOOK] Inventing the Future
L Thompson, 2005 - books.google.com
... A **nanorobot** on a strand of hair f **nanorobots** can clean inside our **...** You won't be able to feel **nanorobots** in your blood or on **...** Dr Nakamatsu is a modern **inventor**. **...**

Hybrid control system for collectives of evolvable **nanorobots** and microrobots
N Solomon, 2008 - freepatentsonline.com
... are structured into single **nanorobot**, local network **...** In the case of **nanorobotics** and microrobotics, each **...** entities, the collectives of **nanorobots** and microrobots **...**

System and methods for immunocomputing applied to collectives of **nanorobots**
N Solomon, 2008 - freepatentsonline.com
... medicine, the application of EHW to **nanorobotics** (N-EHW **...** regarding the precise positions of the mobile **nanorobots**. Each **nanorobot** has a tag or signal that tracks **...**

System and methods for collective **nanorobotics** for medical applications
N Solomon, 2008 - freepatentsonline.com
... Develop multi-functional **nanorobotics**. Develop systems in which **nanorobots** work together. **...** Develop an external tracking procedure for a **nanorobot**. **...**

A **NANO-ROBOTS** SYSTEM AND METHODS FOR WELL LOGGING AND BOREHOLE …
P SINGH, S BHAT, 2009 - wipo.int
... Abstract: This **invention** relates to a **nano-robots** system and methods for well logging and borewell measurements. In one embodiment, a **nano-robot** includes a **...**
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NANOROBOTICS SYSTEM
N SOLOMON, 2008 - wipo.int
... Title: **NANOROBOTICS** SYSTEM. Abstract: The **invention** pertains to hybrid control systems for collectives of **nanorobots** that exhibit intelligence, social behavior **...**
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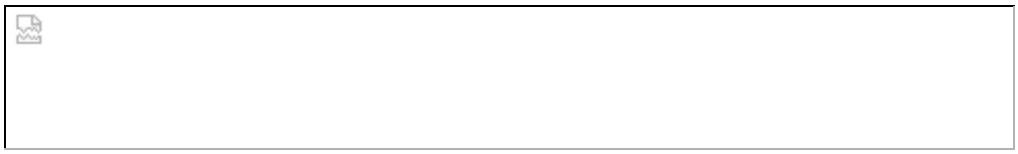

Solomon Research LLC Announces Strategic Alliance with PatentBridge LLC as Sole Agent to License Intelligent Systems Technologies to Major Corporations Worldwide

.August 1, 2005

Solomon Research LLC has agreed to work exclusively with PatentBridge **LLC** in a patent licensing arrangement.

Solomon Research invents intelligent systems applications for networking, robotics, customization and biotechnology. Its technologies solve major problems involving the emerging **research** program of complexity science, a revolutionary scientific theory dealing with dynamic self-organizing systems such as economics and biology. With as many as several hundred patents pending worldwide the **Solomon Research** technologies are extensive. Neal **Solomon**, who holds degrees from Reed College and The University of Chicago, has been issued pioneer patents on robotics in the U.S. and on commercial and networking technology in the U.K.

The inventions in the **Solomon** patent portfolios involve a range of novel technologies concerning intelligent systems including (a) information technology (customized commercial and education systems), (b) computer science (advanced databases, networks and routing), (c) engineering systems (collective robotics for industrial and military applications) and (d) biotechnology (bioinformatics for personalized medicine). The substantial collection of patents will be licensed to prospective customers in a range of industries on several continents.

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Since PatentBridge is primarily interested in patents for high value business opportunities, the **Solomon Research** patent portfolios are an excellent strategic fit. According to Mr. Holmes, the **Solomon Research** patent portfolios are not merely innovative, but revolutionary, because they represent numerous innovations

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For more information about these businesses, see our web sites at www.solomonresearch.com and www.patentbridge.com.

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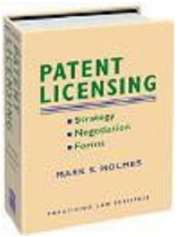
Date	Program	Topic
April 27, 2009	2009 PLI Advanced Licensing Program Chicago www.pli.edu	Moderator "Analysis of a Complex Technology License" Speaker "Software Licensing"
March 26, 2009	2009 PLI Advanced Licensing Program New York www.pli.edu	Moderator "Analysis of a Complex Technology License"
March 18, 2009	LES Silicon Valley Chapter 2009 Annual Meeting Hewlett-Packard, Palo Alto	Moderator "Funding the New Venture in Hard Times: Friends and Family-Angels-Venture Capital"
March 2, 2009	2009 Patent Law Institute New York www.pli.edu	Speaker "Business Considerations of a License Agreement"
Feburary 26, 2009	2009 PLI Advanced Licensing Program New York www.pli.edu	Moderator "Analysis of a Complex Technology License" & Speaker "Software Licensing"
November 19, 2008	Hawaii State Bar Association Honolulu, Hawaii	Speaker "Impact of Recent Supreme Court and Federal Circuit Cases on Patent Licensing"
October 18, 2008	2008 Annual Meeting Licensing Executives Society (LES) Orlando, Florida	Speaker "Silicon Valley Strategies for Successful Licensing – What the Experts in Silicon Valley are Doing"
June 11, 2008	2008 PLI Advanced Patent Licensing Program San Francisco www.pli.edu	Co-chair and speaker “Analysis of a Patent License Agreement”



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2000 - present (annual supplement)	PLI Treatise Series www.pli.edu	Patent Licensing: Negotiation, Strategy and Forms
April 2006	Metropolitan Corporate Counsel www.metrocorpcounsel.com	Analyzing Selected Provisions Of A Complex Technology Agreement
December 2002	Hosting Tech Magazine www.hostingtech.com	So, Who's In Charge Of Your Software Licenses? (quoted at length)
February 2002	California Lawyer www.dailyjournal.com	Expert Advice: Outsourced Tech (Using outsourced computer applications)
May 2000	Communication News, American Society of Association Executives (ASAE), www.asaenet.org	Copyright in the Digital World
April 2000	Association Management (ASAE) www.asaenet.org	Ready for an e-Read?, Co-authored with Gerry Romano

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		"Software Licensing"
January 28, 2008	2008 Patent Law Institute San Francisco www.pli.edu	"Business Considerations of a License Agreement"
January 14, 2008	2008 Patent Law Institute New York City www.pli.edu	"Business Considerations of a License Agreement"
January 8, 2008	Patent Claim Construction San Francisco www.lawseminars.com	Business Strategies in Patent Portfolio Management
October 31, 2007	LES Silicon Valley Chapter Luncheon Applied Materials, Santa Clara www.les-svc.org/Events.html	Panelist "Licensing The Future"
Sept. 1, 2007	Renaissance Weekend Monterey, California	Panelist "Launching Startups"
June 13, 2007	2007 PLI Advanced Patent Licensing Program San Francisco www.pli.edu	Co-chair and speaker "Analysis of a Patent License Agreement"
May 30, 2007	2007 PLI Advanced Patent Licensing Program New York City www.pli.edu	Co-chair and speaker "Analysis of a Patent License Agreement"
April 27-29, 2007	2007 Joint Meeting of the Washington State Patent Law Association and the Oregon Patent Law Association Stevenson, Washington	"Hot Issues in Patent Licensing"
March 28-29, 2007	2007 PLI Advanced Licensing Program New York www.pli.edu	Software Licensing and Analysis of a Complex Technology License
March 1-2, 2007	2007 PLI Advanced Licensing Program San Francisco www.pli.edu	Software Licensing and Analysis of a Complex Technology License

March 21, 2007	LES Silicon Valley Chapter Annual Meeting Hewlett-Packard, Palo Alto	Moderator: "VC's and Patents"
January 29-30, 2007	Patent Law Institute San Francisco	"Business Considerations of a License Agreement"
August 24-25, 2006	Cross-Border IP Licensing Vancouver, BC www.lawseminars.com	"Special Issues in Patent Licensing"
July 13 - 14, 2006	Modern Licensing Law San Francisco www.lawseminars.com	Co-Chair and Speaker, "Patent Licensing"
June 14, 2006	2006 PLI Advanced Patent Licensing Program San Francisco www.pli.edu	Co-chair and speaker "Analysis of a Patent License Agreement"
May 31, 2006	2006 PLI Advanced Patent Licensing Program New York City www.pli.edu	Co-chair and speaker "Analysis of a Patent License Agreement"
May 24 - 25, 2006	Corporate Counsel's Guide to Software Patents San Francisco www.americanconferenc-e.com	Speaker, "Patent Assertion Licensing"
March 28, 2006	World's Best Technologies Showcase, produced in cooperation with the Federal Laboratory Consortium for Technology Transfer (FLC) and the National Association of Seed and Venture Funds (NASVF), Dallas www.wbtshowcase.com	Deal Screener and Speaker: "The Licensing Decision"
March 16-17, 2006	2006 PLI Advanced Licensing Program San Francisco www.pli.edu	Software Licensing and Analysis of a Complex Technology License
March 7-8, 2006	PLI 2006 Advanced Licensing Program New York City www.pli.edu	Software Licensing and Analysis of a Complex Technology License
January 11, 2006	Chinese Industry and Government Delegation, Hunan IV Program, International and Extended Studies San Jose State University	Faculty, "International Intellectual Property Practice: America-China Case Analysis"
November 9, 2005	BioWest 2005 Denver, Colorardo www.biowestconference. com	Speaker, "Licensing in Bioscience"
June 29, 2005	2005 PLI Patent and High Technology Licensing Program San Francisco & Los Angeles (via satellite) www.pli.edu	Co-chair and speaker "Analysis of a Sophisticated Technology License Agreement"
June 25, 2005	Nevada Inventors Association Reno, Nevada www.nevadainventors.-org	Speaker "Determining Reasonable Royalty Rates for Patents"

June 1, 2005	2005 PLI Patent and High Technology Licensing Program New York City www.pli.edu	Co-chair and speaker “Analysis of a Sophisticated Technology License Agreement”
April 12, 2005	LES Silicon Valley Chapter Fifth Annual Conference Hewlett-Packard Palo Alto, California www.les.org	Speaker, "Creating New IP Ventures"
March 24, 2005	LES Professional Development Series (PDS) www.usa-canada.les.org	Instructor, Living with the Deal (Managing Intellectual Assets)
March 17, 2005	2005 PLI Advanced Licensing Program San Francisco & Los Angeles (via satellite) www.pli.edu	Speaker, "Software Licensing and Analysis of a Complex Technology License"
March 7, 2005	PLI 2005 Advanced Licensing Program New York City & Boston (via satellite) www.pli.edu	Speaker: "Software Licensing and Analysis of a Complex Technology License"
October 17, 2004	Licensing Executive Society (LES) Annual Meeting Boston www.les.org	Speaker "Creating New IP Ventures: Profiting from Intellectual Property"
August 3, 2004	International Society for Optical Engineering (SPIE) Annual Meeting Denver www.spie.org	Speaker, "Strategic Use of Intellectual Property"
June 29, 2004	PLI 2004 Patent and High Technology Licensing Program San Francisco & Los Angeles (via satellite) www.pli.edu	Co-chair and speaker “Consulting and Know-How Agreements”
June 2, 2004	PLI 2004 Patent and High Technology Licensing Program New York City www.pli.edu	Co-chair and speaker “Consulting and Know-How Agreements”
March 8, 2004	PLI 2004 Advanced Licensing Program New York City & Boston (via satellite) www.pli.edu	Software Licensing and Analysis of a Complex Technology License
March 18, 2004	PLI 2004 Advanced Licensing Program San Francisco & Los Angeles (via satellite) www.pli.edu	Software Licensing and Analysis of a Complex Technology License
February 11, 2004	Licensing Executive Society (LES) Winter Meeting San Francisco www.les.org	Speaker: Add-On, Best Practices in Licensing Moderator: "Patent Search Technology for Non-Obvious Licensing Opportunities"
September 23, 2003	Licensing Executive Society (LES) Annual Meeting San Diego www.les.org	“Licensing Trade Secrets in Academia: Laudable or Laughable?” Co-presented with David Aston, Chief Patent Counsel, Lawrence Berkeley National

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September 17, 2003	Intangibles IQ: Innovation and Shareholder Value Conference, Intercontinental Hotel San Francisco www.intangiblesiq.com	Best Practices in Intellectual Property Licenses
June 25, 2003	PLI 2003 Patent and High Technology Licensing Program San Francisco & Los Angeles (via satellite) www.pli.edu	Co-chair and speaker “Consulting and Know-How Agreements”
June 10, 2003	PLI 2003 Patent and High Technology Licensing Program New York City & Boston (via satellite) www.pli.edu	Co-chair and speaker “Consulting and Know-How Agreements”
April 30, 2003	LES Silicon Valley Chapter, Monthly Meeting Cadence Design Systems San Jose www.les.org	Speaker, "The Most Heavily Negotiated Aspects Of Patent Licensing"
March 20-21, 2003	PLI 2003 Advanced Licensing Program San Francisco & Los Angeles (via satellite) www.pli.edu	Software Licensing and Analysis of a Complex Technology License
March 10-11, 2003	PLI 2003 Advanced Licensing Program New York City & Boston (via satellite) www.pli.edu	Software Licensing and Analysis of a Complex Technology License
June 26, 2002	PLI 2002 Patent and High Technology Licensing Program, New York City & Boston (via satellite) www.pli.edu	Co-chair and speaker “Consulting and Know-How Agreements”
June 10, 2002	PLI 2003 Patent and High Technology Licensing Program, San Francisco & Los Angeles (via satellite) www.pli.edu	Co-chair and speaker “Consulting and Know-How Agreements”

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The thirteenth annual Conference on Mechatronics and Machine Vision in Practice

Will be held December 5-7 2006 in Toowoomba, close to Brisbane, Australia

Call for papers

Please send two-page (equivalent) extended abstracts by plain-text email to johnbill@usq.edu.au, with the subject heading "M2VIP abstract" to arrive before May 1st, 2006 - the earlier the better. See www.m2vip.com for details.

The topics of the conference are defined in its title, Mechatronics and Machine Vision in Practice - and the emphasis is on practical applications. Special encouragement is given to applications of robotics and machine vision in agriculture.

The international panel of referees will select the abstracts they wish to review from a list of titles. They will be sent email abstracts that had been edited to make them anonymous. They are asked to make a judgment based on:

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Machine-vision has emerged from the laboratory to find real applications in areas which include vehicle guidance, robot control and agriculture. Low-cost cameras have been developed for multimedia applications - but with their ease of interfacing they offer a whole new field of low-cost vision-based control.

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Presentations are encouraged to include video material of experimental systems.

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Computational Nanorobotics: Agricultural and Environmental Perspectives

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Abstract—**Recent developments in molecular fabrication, computation, sensors and motors will enable the manufacturing of nanorobots. The present work contributes with such aim, describing a platform suitable for the design and manufacturing research, using computer simulation and system on chip for prototyping. The use of CMOS as integrated circuits, with the miniaturization from micro towards nanoelectronics, and the respective advances of nanowires are considered into the proposed model design and discussed as a suitable path-way to enable embedded sensors for manufacturing nanorobots. The proposed nanorobot model is applied to hydrology monitoring with aims focused on economical aspect related to agriculture or production based on natural resource activities. Moreover, the use of nanorobots in enviromental monitoring is also presented. Teams of nanorobots could be used to patrol a hydrological predefined area.**

Index Terms—**Agricultural management, control systems, electromagnetic sensors, environmental monitoring, hydrology, lithography, manufacturing, mechatronics, mesoscopic nanowires, nanorobots, nanotechnology, nanotubes, NEMS, photonics, SoC, transducers, VHDL, VLSI, virtual reality.**

1. INTRODUCTION

This paper presents an innovative approach to evaluate hydraulic conductivity, considering nanorobots as a paradigm capable to open new perspectives in the field of hydrology monitoring. The application of nanorobots for agricultural purposes and monitoring water and soil qualities may result in impressive impact towards environmental control and decreasing the damages caused by pollution to many different natural species. Applications of nanorobots are expected to provide remarkable possibilities. Recent developments in the field of biomolecular computing [2], [53], [10] have demonstrated the feasibility of processing logic tasks by bio-computers [17], which is a promising first step to enable future nanoprocessors with increased complexity. Studies targeted at building biosensors [40], [7] and nano-kinetic devices [39], required to enable nanorobotics operation and locomotion, have been advancing recently as well.

Over the past 15 years, we have gained insight into the hydraulic conductivity of fractured and karstic rocks by introducing particles of different size, charge, and chemical composition into a flow field and monitoring the breakthrough of these particles in space and time. From this information, we may infer the hydraulic aperture of the smallest throats in a flow path. Therefore we may be able to extend this concept to porous media using nanorobots [49]. We describe a computational approach for the investigation of nanorobots manufacturing design [8] to enable better tools for hydraulic conductivity interpretation. The nanorobots are using chemical gradients and electromagnetic sensing over short distances along specific flow paths to solute integrated estimates of hydraulic conductivity. Such information acquisition process is quite useful to define geological characteristics, which are at most important when agricultural management or environmental disasters arises requiring efficient decisions in short time, or even more to improve productivity in some industrial activities as described through the paper. A total market for nanotechnology-based environmental applications in 2005 was evaluated in $374.9 million, and by 2010 this market will have reached more than $6.1 billion [5]. Geophysicists have held out hope of ways to describe hydraulic conductivity distribution with new analytical and detection methods and yet, we are little closer to the illumination of this Holy Grail than we were 40 years ago. The limitation of geophysical methods falls into two categories. First, there is a limitation of direct measurement on the size of the features we are looking for (pore throats). These small features require a short wavelength and thus high energy for resolution. Unfortunately, energy is rapidly dissipated in travel through earth material, generally resulting in degraded resolution at the desired scales. This wavelength/energy constraint is fundamental and cannot be overcome. Second, because geophysicists are unable to directly measure the feature of interest, they measure a surrogate of pore-throat sizes. That is, typical geophysical methods measure properties of waves, density, or electrical conductivity, which is used to generate lithologic information.

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Abstract: This paper describes an innovative work for nanorobot design and manufacturing, using a computer simulation and system on chip prototyping approach. The use of CMOS as integrated circuits, with the miniaturization from micro towards nanoelectronics, and the respective advances of nanowires are considered into the proposed model design and discussed as a practical pathway to enable embedded sensors for manufacturing nanorobots. The proposed nanorobot model is applied to hydrology monitoring. It can be useful for agriculture or environmental monitoring and management.

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Uncontrolled terms: computational nanomechatronics - nanorobot control - nanorobot manufacturing - nanorobot design - computer simulation - system on chip prototyping approach - CMOS - integrated circuits - nanoelectronics - nanowires - embedded sensors - hydrology monitoring - agriculture - environmental monitoring

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ANATOMY OF THE KURZWEIL FRAUD

How Kurzweil's straight-arrow CEO went awry

On September 11, Bernard F. Bradstreet will stand before a federal judge in Boston to receive a dubious distinction accorded only a handful of his fellow Harvard business school graduates: He will be sentenced to jail.

The 51-year-old former president and co-chief executive of Kurzweil Applied Intelligence Inc. was convicted in May of masterminding an astonishingly blatant accounting fraud at Kurzweil, a small but leading-edge player in computerized speech recognition based in Waltham, Mass. With Bradstreet at the helm, the company booked millions of dollars in phony sales in the two-year period straddling its August, 1993, initial public offering. Although supposedly sold to customers, the goods instead were shipped to a local warehouse, where they gathered dust.

BILKED INVESTORS. To hide the scheme from outside auditors, prosecutors contended, Bradstreet and other managers forged customer signatures, altered or concealed crucial documents, and surreptitiously shifted unsold goods between warehouses. The scheme allowed Kurzweil to show profits when it was really losing substantial amounts of money, in effect bilking the investors who plowed $24 million into the company's stock offering. When the fraud was finally exposed in mid-1994, the bottom dropped out of Kurzweil's stock. From a high of 21 in late 1993, the stock has sunk to about 2 1/2, and the company is still struggling to recover.

Despite the enormity of the chicanery and the large number of employees involved, it eluded not only auditors but also Kurzweil's outside directors and Robertson, Stephens & Co., which underwrote the IPO. In hindsight, these external watchdogs missed telltale signals, including soaring receivables. But it's often difficult to uncover fraud perpetrated by top management. And in the Kurzweil case, detection was made harder by the willingness of executives to brazenly lie and forge documents.

The involvement of Bradstreet in this sordid affair is especially bizarre. A

former Marine fighter pilot who favored short hair and buttoned-down shirts, Bradstreet struck numerous associates over his 20-year career as the epitome of an honest and straightforward executive. ``He was a highly ethical family man,'' recalls Richard B. Goldman, a former chief financial officer at Prime Computer Inc., where Bradstreet worked as treasurer from 1979 to 1985. ``Certainly, the guy I knew wouldn't knowingly perpetrate the kinds of things he has been accused of.''

Indeed, Bradstreet's apparent role in the fraud seems to defy logical explanation. With his background, he should have realized that such a crude scheme would inevitably be uncovered. And the usual explanation for such events--greed--doesn't seem convincing in this case. Even had the fraud succeeded, there was no big payday in store for Bradstreet: He owned just 3.4% of the company, worth barely $1 million at the time of the IPO.

``CLEAR-CUT CASE.'' On the witness stand, Bradstreet admitted the company had improperly accounted for some of its sales. But he contended the errors were the responsibility of underlings and said he didn't know about the apparent fraud until the very end. Prosecutors undermined that argument with a raft of evidence and the testimony of their star witness, former Kurzweil Treasurer Debra J. Murray. A quiet secretarial school graduate, Murray had worked closely with Bradstreet for nine years. She testified in mind-numbing detail that her former boss had directed or approved almost every step of the fraud.

Jeffrey B. Rudman, a senior attorney at Hale & Dorr in Boston who headed an investigation into the fraud for Kurzweil's outside directors, calls the scheme ``the most clear-cut case with which I've ever been involved. The tragedy is that a very honorable and good man did something inexplicable in light of his history. That's what makes it so painful. What went wrong?''

Besides Bradstreet, at least 10 other employees were directly or tangentially involved. One junior accounting staffer even dummied up a phony logbook to help fool auditors, using three different inks to escape detection. Several salesmen testified they forged documents and otherwise aided in the scheme. But none of these low-level staffers were charged. Instead, prosecutors used their testimony to snare the big fish. Former Vice-President for Sales Thomas E. Campbell was found guilty of fraud and conspiracy charges alongside Bradstreet. Murray pleaded guilty and got probation.

The Kurzweil case raises the troubling question of why a group of otherwise law-abiding citizens veered into illegal behavior. One possible motivation may have been the unrelenting pressure on public companies to satisfy Wall Street's demands for steady quarterly growth. There's a huge temptation to push the accounting envelope, to enhance numbers by bending rules slightly. More than a few managers succumb to the lure and don't get caught. But how did the Kurzweil team go from bending to shattering the rules?

Unfortunately, the deepest motivations of the key players can only be surmised. Through their attorneys, Bradstreet and Campbell declined to be interviewed for this article, and Murray also demurred. But thousands of pages of trial transcript, plus interviews with numerous participants, provide

an extraordinarily detailed picture of how a promising young company derailed.

``SQUEAKY-CLEAN.'' The Kurzweil saga starts with the company's founder, Raymond C. Kurzweil, now 48. A computer prodigy, at age 28 he invented a machine that could scan printed material and read it aloud to the blind, using synthesized speech. In 1982, he founded Kurzweil Applied Intelligence to commercialize his speech-recognition research, in this case using computers to transform spoken words into printed text. The idea was sexy enough to attract some big-name backers, including Harvard University's endowment fund and Xerox Corp.'s venture-capital arm.

Meanwhile, Bradstreet was compiling an impressive resume. After attending Harvard College on an ROTC scholarship, he spent five years as a Marine fighter pilot and air combat instructor during the Vietnam War, becoming a captain. Then came Harvard B-school, where former classmates remember ``Brad'' as hard-working and unusually devoted to his wife, Carol. ``He was honorable, decent, steady, and straight as rain, not flashy at all,'' recalls Marguerite A. Piret, a fellow 1974 graduate.

After a stint as a loan officer at First National Bank of Chicago, Bradstreet in 1979 took the treasurer's job at Prime. There, he struck co-workers as hyperconservative. ``Bernie was squeaky-clean,'' says John R. Colbert, who worked under Bradstreet as assistant treasurer. ``He didn't even swear.''

Looking for a more entrepreneurial career, Bradstreet jumped to Kurzweil in 1985 as chief financial officer. At the time, the company had only a few dozen employees and almost no revenues. Bradstreet soon realized that the company's technology, though promising, was too costly and underdeveloped for the broad electronic-dictation market. Bradstreet persuaded the company to focus on the medical field, using Kurzweil gear to help doctors dictate electronic medical records. Gradually, Bradstreet took on bigger roles, first as president, then as co-CEO with Ray Kurzweil, while also retaining his CFO job. By 1991, he was in charge of all day-to-day operations.

Progress in penetrating the medical market was far slower than anticipated, in part because the technology was tricky to perfect. But by early 1992, insiders had a feeling Kurzweil was on the verge of a breakthrough. The company had moved into the black, posting a slim profit of $111,000 in 1991 on revenues of $10.5 million.

Both Bradstreet and Ray Kurzweil, who remained co-CEO until 1994 but was concerned chiefly with technical matters, were itching to take the company public. But according to the testimony of several Kurzweil employees, Bradstreet was convinced the company needed to post six straight quarters of improving results to make the IPO happen. Trouble was, Kurzweil's systems were a difficult sell, requiring big financial commitments from hospitals to a completely new technology.

Kurzweil's slow slide into fraud started in a fairly innocuous manner during 1991, Murray testified. If a quarter was ending but a sales rep needed a few

days to cement a sale, she said, Bradstreet began allowing the company to book the revenue a bit early. Instead of being shipped to the customer, the goods were ``temporarily'' stored at a Chelsea (Mass.) warehouse called FOB America until the order was signed. Under generally accepted accounting principles, a sale can only be counted when goods leave the company's premises en route to the customer. But the maneuver was impossible to detect as long as the sale was consummated quickly.

As sales proved harder to get during 1992, the company relaxed its policy to allow sales to be booked two weeks early. And by the following year, Murray testified, the rules were stretched until ``the whole policy basically went out the window and [we did] whatever was necessary to book the revenue."

Aggressive accounting started to veer into chicanery. The turning point may have come in the final hours of Dec. 31, 1992. With the company still short of its quarterly targets, Campbell was pressuring Atlanta salesman James Hasbrouck to seal two orders from Georgia hospitals. Although Hasbrouck testified he told Campbell the customers weren't ready to sign, Campbell kept pushing, and the salesman eventually forged both customers' names on sales papers and faxed them to Campbell.

Soon after, Murray testified, Campbell came charging into her office with the $221,000 in ersatz orders. Campbell confided to her about the forgeries, saying Hasbrouck needed more time to ``clean up the paperwork." Murray informed Bradstreet, she testified, and he told her not to worry--although Bradstreet countered in court that he didn't know about the forgeries. Murray posted the transactions.

Yet Hasbrouck never did secure the deals. Murray testified that she repeatedly asked Bradstreet what to do about the now bogus sales, but he told her to keep the sales on the books because Kurzweil ``needed to meet [a] certain revenue number in order for the public offering to continue." The equipment sat in storage until the fraud was uncovered nearly 17 months later.

Ethics experts say the decision to keep the phony revenues may have arisen from a misguided sense of loyalty. ``Executives in this type of situation often have an emotional investment in the company," says Barbara Ley Toffler, who heads an ethics consulting unit at Arthur Andersen & Co. ``They have all this wonderful stuff to offer the world. So they rationalize. They say, `We'll do this temporarily, and that will give us time to make it all come out right.' But instead, they dig themselves in deeper."

Not long after, the fakery nearly caused the scheme to prematurely unravel. As part of the annual audit, Coopers & Lybrand accountants sent letters to both customers, asking for confirmation of the orders. After Murray put pressure on Hasbrouck to find a solution, the salesman testified, he retrieved the unsigned confirmation letter from one of the customers, again forged the signature, and faxed it to the auditors. Bradstreet and Campbell knew about this maneuver, Murray testified. The unwitting auditors gave Kurzweil a clean bill of health.

With the IPO planned for the summer of 1993, the first quarter of the new fiscal year would be the final one listed in the prospectus. But once again, sales were slow, and Murray testified that Bradstreet authorized her to book another series of questionable deals.

PAPER TRAIL. Late on the final afternoon of the quarter, with revenues still behind target, Bradstreet made a move that for the first time linked him directly to the fraud's paper trail. To reassure another customer, Bradstreet hurriedly signed and faxed a letter that a $450,000 order would be ``contingent on our mutual agreement of the final document.'' This side letter meant that the customer hadn't actually agreed to buy anything. But Bradstreet told Murray to book the sale as a done deal. He never showed her the side letter, she testified, and the transaction didn't close until the following year. At the trial, Bradstreet defended his decision. But he conceded nailing down the details of the sale took longer than he expected.

On Aug. 24, the IPO finally closed. Investors paid $10 apiece for 2.4 million shares, 35% of the company's stock. Bradstreet sold $115,000 worth of his own shares. Although associates say Bradstreet didn't live an extravagant lifestyle, there were signs he might have needed the money. On his $200,000 annual salary, he was paying private-school tuition for his three children. And county records show that he had been borrowing money by increasing the mortgage on his house, a five-acre spread in the tony suburb of Sudbury. The mortgage started at $220,000 in 1983; by the early 1990s, it was up to $448,000.

How did Bradstreet hope to get out of this mess? The most likely explanation, say outside experts, is that he was counting on a surge in revenues so the company could continue to show growth over its prior (inflated) quarterly numbers. He presumably also hoped the sales force could find customers for the excess goods sitting at FOB America.

Neither one happened. Instead, prosecutors charged that about two dozen more improperly-recorded sales were used to pump up revenues in the next three quarters of the fiscal year ended Jan. 31, 1994. Trial evidence suggests that of the $18.4 million in sales recorded by Kurzweil that year, at least $6.3 million should not have been included. Through it all, Bradstreet continued to present a picture of confident leadership. He hosted informal weekly lunch meetings for the entire staff and never gave a clue, say employees, that anything was other than rosy.

PURGING FILES. With the next big audit looming in early 1994, Murray instructed her staffers to purge files of compromising material. She testified that she also was very concerned about a transaction booked the prior July involving Florida Health Care Inc., a health maintenance organization in Daytona Beach, Fla. A marketing rep then at the HMO, David W. Spearin, had expressed interest in buying Kurzweil gear, but the deal never went anywhere. Unbeknownst to him, Kurzweil had processed a $274,000 sale to his company--without a shred of paperwork to back it up.

Just before the audit, Murray said, she told Bradstreet they couldn't face the

auditors without a signed order from Florida Health Care. She testified that he told her to give the papers to Campbell. The next morning, they appeared in her in-box, signed ``Dave Spearin.'' The handwriting, Murray testified, appeared to be Campbell's. After the auditors picked Florida Health Care for a confirmation letter, Murray says, Campbell again stepped in, and the letter was signed in the same handwriting.

All this came as a shock to Spearin, who says the signatures are a far cry from his usual scrawl. The whole thing, he says, ``is crazy. We never even came close to buying this equipment.'' He, too, testified for the prosecution.

But it was a seemingly innocuous slip of paper that finally brought the curtain crashing down. On April 14, a Coopers & Lybrand staffer was routinely checking shipping invoices from FOB America when he noticed a charge for nine months' storage on an order that was supposed to have been shipped the prior April. The auditors confronted Bradstreet and Murray, who told them it must be a mistake. Undeterred, the auditors demanded a list of everything stored at FOB America. A panicked Murray said she told Bradstreet that the auditors might suddenly show up at FOB America, and they needed to move the goods to a new hiding place. The next day, the goods were shifted to a warehouse on Cape Cod.

Bradstreet's explanation was quite different. He testified that, after the auditors found the invoice, he quizzed Murray, and she told him--for the first time--about the huge amount of merchandise at FOB America. He decided to secure the goods by moving them until they could be properly accounted for. But prosecutors poked holes in this account, pointing out he failed to alert auditors or the board about the hidden computer gear.

The outside directors, meanwhile, called in Hale & Dorr to investigate. But even with auditors and attorneys crawling all over Kurzweil headquarters, Bradstreet kept his fighter-pilot cool. According to Murray, he began planning to bring the still hidden goods back to Kurzweil, hoping to pretend they had been returned by customers. Murray, however, was getting cold feet. She testified that she told Bradstreet she wouldn't help. ``Isn't it a little late for that?'' she recalled him replying.

TEARS. The lawyers were making little headway until they got a huge break. On May 17, Murray confessed everything in an interview with Hale & Dorr. Merriann Panarella, the Hale & Dorr attorney, vividly recalls Murray calmly producing a chart detailing every questionable transaction. It was, she recalls, ``one of the most poignant moments I've ever had practicing law. Both of us were on the verge of tears.''

A few days later, Bradstreet, Murray, and Campbell were forced to resign by the board. Among the casualties in the ensuing purge were Murray's entire accounting staff and most of the sales force. The scandal nearly devastated the company. Unsure whether Kurzweil would survive, customers slowed orders to a crawl.

New CEO Thomas E. Brew Jr., a crisis specialist brought in the day Bradstreet resigned, is still struggling to turn the situation around. A few

months ago, Kurzweil launched two new software products as advanced as anything on the market. Brew predicts the company will move into the black next year. ``We're confident we've put the accounting irregularities behind us," he says.

Of the top managers, only Ray Kurzweil remains with the company, albeit as chief technical officer, not co-CEO. Murray told the FBI she thought Kurzweil was aware of questionable activity, but he vehemently denied it, and prosecutors apparently concluded he had no direct involvement. Today, he says he still can't fathom why colleagues with whom he had worked closely for years could have resorted to fraud.

As for Bradstreet and Campbell, they face almost certain jail time. Sentencing guidelines call for Bradstreet to receive up to 10 years, while Campbell could get nearly six. Most observers expect the judge to be somewhat lenient, given the pair's previously spotless records. But Bradstreet, in particular, should have plenty of time behind bars to ponder a question that only he can answer: What went wrong?

By Mark Maremont in Waltham, Mass.

BusinessWeek

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(WO/2007/001962) SYSTEMS AND METHODS FOR GENERATING BIOLOGICAL MATERIAL

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Inventor: **KURZWEIL, Raymond, C.**; (US).

Agent: **MALONEY, Denis G. et al.**; Fish & Richardson PC, PO Box 1022, Minneapolis, MA 55440-1022 (US) .

Priority Data: 60/692,327 20.06.2005 US

Title: SYSTEMS AND METHODS FOR GENERATING BIOLOGICAL MATERIAL

Abstract: The invention relates to systems and methods for synthesizing biological material.

Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
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The Open Road
November 13, 2007 12:56 PM PST

Who is the world's biggest patent troll?

by Matt Asay

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In two consecutive days, *The Wall Street Journal* presented two different answers. The first is not surprising: **Intellectual Ventures**, the brainchild of ex-Microsoft executive Nathan Myhrvold. It's now out "to **raise as much as $1 billion to help develop and patent inventions**, many of them from universities in Asia." I know I will sleep so much more comfortably knowing that IVL will be out plundering Asia so that it can turn around and plunder the rest of the planet.

The second might surprise you: the University of California. The University of California may be especially pernicious because it **can sue for patent infringement but has sovereign immunity**:

> In the lucrative world of patents, the University of California is a major player. It receives by far more patents from the U.S. government than any school in the country. And by licensing out its intellectual property, the university has generated about $500 million in revenue in the past five years.
>
> The school also aggressively uses the courts as a sword, and is unafraid to take on big companies. As a plaintiff alleging patent infringement, the school has settled a claim against Genentech Inc. for $200 million, secured a payment of $185 million from Monsanto Co., and won a $30 million settlement from Microsoft Corp.
>
> Yet, when it comes to getting sued for patent infringement, the university, as well as the state of California, are Teflon. A legal doctrine known as sovereign immunity protects states and state institutions from legal liability. Courts have held that participating in the federal patent system doesn't cost a state its immunity. The upshot--states can sue, but effectively can't be sued.

A benevolent troll, perhaps, lovingly educating the nation's children. But one that wields a Teflon fist in a way that no patent holder should.

At least with IVL we know that it's just an avaricious troll, **whatever Myhrvold may say to the contrary**:

> Some university officials--including those from Stanford and MIT--say they aren't working with (IVL) because they worry it could use its patents for litigation or other purposes that don't promote innovation (gasp!). Myhrvold says their concern is overblown, as his company has numerous deals to buy or license patents with more than 80 universities. He says his firm simply wants to get "fair compensation" for new inventions, and help inventors do the same, and that its goal has always been to

> create a more liquid IP market.

He truly is a child of Microsoft. The apple doesn't fall too far from the tree.

The University of California's patent trolling is worse, for the reasons noted above. It's an unfair advantage that should be abolished, **as Stanford Law School professor Mark Lemley argues**:

> The underlying problem is that the Supreme Court is applying an antiquated doctrine--the 11th Amendment--to circumstances in which it was never intended to apply. The Framers never contemplated states suing people for patent infringement.

At least IVL doesn't hide behind state sovereignty, though it does hide behind specious arguments as to the good it brings humanity. Something is clearly wrong when a state can stripmine the IP landscape with impunity.


Matt Asay is chief operating officer at Canonical, the company behind the Ubuntu Linux operating system. Prior to Canonical, Matt was general manager of the Americas division and vice president of business development at Alfresco, an open-source applications company. Matt brings a decade of in-the-trenches open-source business and legal experience to The Open Road, with an emphasis on emerging open-source business strategies and opportunities. He is a member of the CNET Blog Network and is not an employee of CNET. You can follow Matt on Twitter @mjasay.

Topics: **Microsoft**, **Industry news**, **Licensing**

Tags: **patents**, **University of California**, **state sovereignty**, **Intellectual Ventures LLC**, **patent troll**

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(WO/2008/063473) NANOROBOTICS SYSTEM

Latest bibliographic data on file with the International Bureau

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Publication Date: 29.05.2008
International Application No.: PCT/US2007/023775
International Filing Date: 13.11.2007

IPC: ***B82B 1/00*** (2006.01)

Applicant: **SOLOMON, Neal** [US/US]; (US).

Inventor: **SOLOMON, Neal**; (US).

Priority Data: 60/865,605 13.11.2006 US
60/912,133 16.04.2007 US

Title: NANOROBOTICS SYSTEM

Abstract: The invention pertains to hybrid control systems for collectives of nanorobots that exhibit intelligence, social behavior and environmental interaction. The collectives of nanorobots (CNRs) use software agents and metaheuristics, such as hybrid genetic algorithms, to solve optimization problems in evolving environments involving resource constraints.

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DEPARTMENTS

Art Fraud Forensics

An engineer helps curators foil forgers

BY SUSAN KARLIN // JULY 2009

How many engineering jobs let you take a van Gogh off the wall and hold it in your hands? The kind C. Richard Johnson Jr. landed. He's both an electrical engineering professor at Cornell University, in Ithaca, N.Y., and an adjunct research fellow at the Van Gogh Museum, in Amsterdam. As such, Johnson says, he can "speak the language of people on both sides."

And when the two sides talk, they mainly talk about fraud and how to detect it. Two years ago, Johnson organized a conference at the museum that brought together researchers from Pennsylvania State University and Princeton, in the United States and Maastricht University in the Netherlands. Together, they processed high-resolution images with specially designed signal-processing algorithms to help sort fake van Goghs from real ones at the brushstroke level. It was the first time that image-processing teams at different universities could compare authentication approaches on the same paintings. Another workshop will follow next year at the Museum of Modern Art, in New York City.

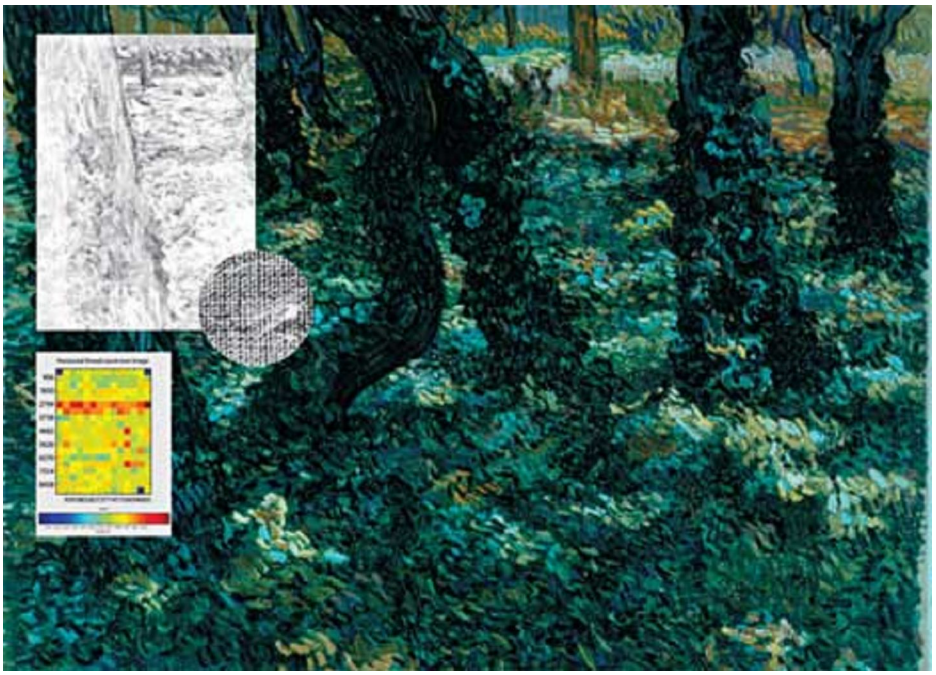

PHOTO: VAN GOGH MUSEUM

Painting by numbers:

C. Richard Johnson [left, center] uses signal-processing algorithms to authenticate canvases believed to be painted by van Gogh.

”Fraud detection is a ’sexy’ topic, which is why it was an early focus of my activities,” says Johnson. ”But we’re 10 to 15 years away from the computer having any authority in it. So now my colleagues and I are pursuing a wide variety of issues of interest to conservators and art historians, where signal processing can provide assistance that reaches well beyond just the detection of frauds.”

Johnson’s current focus is on canvas thread counts—the number of horizontal threads crossing a vertical line 1 centimeter long—to identify paintings from the same roll of canvas. ”Placing a questioned painting on the same canvas roll as a painting known to be from a particular artist supports authentication to an artist who bought canvas in rolls, as van Gogh often did,” he says. ”When canvas is prepared with a lead white ground, the grooves between the threads are filled with radio-opaque material,” says Johnson. ”This registers in an X-ray as an intensity pattern that reveals the individual threads, permitting a calculation of the weave density.” The pattern is then analyzed with a Fourier transform, the same technique that radio engineers use to break down a signal into a series of simple sine waves.

The team is distributing the software free to museums. The Van Gogh Museum already uses the data generated to identify paintings from the same canvas roll by determining how the sections were arranged on the roll before being cut for use.

Johnson stumbled into art as he wandered through Berlin museums during a college year abroad while earning a bachelor’s in electrical engineering from Georgia Tech. Later, while working on his Ph.D. in EE at Stanford, he took a class in the Dutch masters, which rekindled his passion. In 1977, he became the first Ph.D. student to graduate from the university with a minor in art history.

He went straight into academia, teaching at Virginia Tech until 1981, when he moved to Cornell. He was named an IEEE Fellow in 1989 for his work in digital control and signal processing.

”This kind of research is not something to recommend to Ph.D. students. There are no jobs, no one’s eager to fund this, and it’s career killing for any pretenure academic,” he says, laughing. ”But for me, it’s like having a backstage pass. I go to a conservation studio and can take a van Gogh out of its frame and examine it.”

About the Author

Susan Karlin lists among her achievements acting, drawing, traveling to every continent on Earth, and writing for publications such as The New York Times, Entertainment Weekly, and Spectrum. For this issue she follows the trail of a coffee-making cellphone in ”Phone-y Brew” [p. 22] and reports on an electrical engineer who helps museums spot fake van Goghs in ”Art Fraud Forensics” [p. 23].

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The invention relates to systems and methods for synthesizing biological material.
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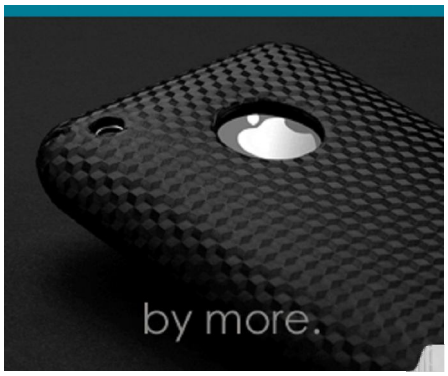

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1. 2008 NANOROBOTICS SYSTEM
SOLOMON, Neal
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2. 2008 System, methods and apparatuses for nanorobotics and microrobotics
Solomon, Neal
A system for nanorobotics and microrobotics is disclosed with apparatuses for (a) assembly of joints, (b) connection of top-down nano structures, (c) micro-pump, (d) nano-balloon and (e) nanosail. The nano-balloon and nanosail apparatuses provide for ...
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3. 2008 System and methods for collective nanorobotics for electronics applications
Solomon, Neal
The invention describes a system for collective nanorobotics (CNRs) for electronics applications. CNRs are used to selectively activate electronics devices and remote devices and to target objects in sensor networks. A method of delivering CNRs in aerosol ...
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4. 2008 System, methods and apparatuses for integrated circuits for nanorobotics
Solomon, Neal
The invention describes apparatuses for nano-scale integrated circuits applied to nanorobotics. Using EDA techniques, the system develops fully functional nano ICs, including ASICs and microprocessors. Three dimensional nano ICs are disclosed for ...

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I don't just write about the **Linux** desktop; I use it every day. At my desk, I tend to use MEPIS and Mint, while on the road, it's Ubuntu on my Dell netbook **...**

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Nokia **Linux** phone rumoured

Inquirer - Ed Berridge - 20 hours ago

The story circulating is that the Nokia N920 could be released with Maemo 6 **Linux** next year. What is strange is that the rumours are starting **...**

Next-gen Nokia **Linux** devices will get multitouch and Qt UI Ars Technica
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Schwarzenegger rescues Ellison keynote from jaws of banality Register
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Oracle enhances server virtualization platform with Oracle VM 2.2 release

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The initial release is based on the 2.6.28 **Linux** kernel which integrates drivers for the full range of LPC3130 reference board peripherals. **...**

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eWeek - Jason Brooks - 15 hours ago

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Schmidt further claims Chrome OS is faster and more efficient than incumbent operating systems, including other **Linux** distributions and Microsoft Windows. **...**

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CTIA: Nokia Demoes N900 Tablet With Maemo and **Linux**

pocketnow.com - Chuong Nguyen - Oct 12, 2009

Unlike traditional Nokia phones that are powered by Symbian, this device runs the Nokia's version of the Maemo OS, which is built on top of **Linux**, **...**

Nokia N900 Smartphone: Apps and future Maemo **Linux** versions Product Reviews (blog)

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Express Computer - 1 hour ago
Linux has established a firm presence in the industry and it is seen a viable platform for supporting the deployment of business-oriented application **...**

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The last RC before final release of Mandriva Linux 2010 is now available
DailyTech - Oct 13, 2009
The team behind the Mandriva **Linux** operating system recently announced the immediate availability of the Mandriva **Linux** 2010 Release Candidate 2. **...**
Mandriva 2010 goes for the full Moblin eWeek
Mandriva One 2010 RC2 ZDNet UK
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Nanotechnology News (press release) - 3 hours ago
The core description of the present initiative is based on **Linux** strategies. The basis and key advantages of such an approach are clearly described next. **...**

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We recently observed someone noting that Xen doesn't provide the same physical-to-virtual (p2v) conversion capabilities that VMware **...**


CXOToday.com

Who really has the most Linux users?
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First, Red Hat's claimed the lion's share of the **Linux** market, then Novell said Red Hat's not that much in the lead, so where does the truth lie? **...**
Windows and Linux Marriage with Cooperative Technical Support Dowry Softpedia
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That's the view of Navin Thadani, a senior director of the **Linux** vendor's virtualization business. "We see consolidation as being inevitable, **...**
Is Xen Out In The Cold? Virtualization Review
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PR Newswire (press release) - Oct 14, 2009
The solution is a simple-to-use product for deploying dual-boot HPC systems that run **Linux** and Windows natively in a single cluster. **...**
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Tom's Guide - 13 hours ago

This is not an issue for Windows compatibility. and **Linux** is also compatible, of course. But Mac OS X, though Unix-based like **Linux**, does not support ext3 **...**
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What the article, from The Washington Post, suggests is that you can use a **Linux** Live CD to boot from and turn your Windows-based PC into a **Linux** PC, **...**


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Future Versions Of Firefox To Detect Screen Orientation
PC World - Chris Brandrick - Oct 13, 2009
... developed for mobile browsers but has now been made available, via an API, for a range of devices including Macbooks, Thinkpads and **Linux** machines. **...**
Firefox 3.6 Will Speak Fluent Accelerometer Gizmodo.com
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Linux equivalents to popular Mac apps
Ghacks Technology News - Jack Wallen - 11 hours ago
In my most recent article ("Five tips to help ease the migration from Mac to **Linux**") I outlined ways to help end-users transfer from the Mac operating **...**

Inside Mac OS X Snow Leopard Server: Apple's server strategy
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United **Linux** and a series of followup attempts to standardize **Linux** all failed to accomplish their aims. A variety of efforts to sell **Linux** to consumers **...**


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Firefox 3.6 Beta 1 "Test Build" Now Available
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Windows/Mac/**Linux**: It's not the official beta of Firefox 3.6—that's been put off for a week. But a "test build" of Firefox 3.6 has landed, with Windows 7 **...**
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Canonical's Ubuntu 9.10 Server Edition will include private cloud capabilities, thanks to support for the open source Eucalyptus project, InfoWorld reports. **...**

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SDTimes.com - Alex Handy - 10 hours ago

In his final keynote of the show, Oracle's CEO Larry Ellison said that his company would continue to support **Linux**, despite its new ownership of Solaris. **...**

Jim Lynch: The More Things Change...

Extreme Tech - Jim Lynch - 2 hours ago

As part of our deal you'll also see partially cloned **Linux** reviews appearing here on ET. I've always suspected that Lance might be a bit on the dotty side **...**

TechCrunch (blog)

Hulu Adds **Linux** Support

PC Magazine - Chloe Albanesius - Oct 9, 2009

Hulu on Thursday launched a **Linux** version of Hulu Desktop and added several publisher tools. The additions are part of Hulu Labs, **...**

Hulu launches **Linux** desktop client Afterdawn.com

Hulu Labs Cooks Up **Linux** Support For Hulu Desktop, New Publisher Tools TechCrunch (blog)

Hulu Desktop Brings Remote-Controlled Streaming to **Linux** Lifehacker

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ChannelWeb - Ed Moltzen - Sep 23, 2009

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Banktech - Oct 14, 2009

Overview: Red Hat Enterprise **Linux** has been designed by, and for, the most security-conscious organizations in the world. Accordingly, security has always **...**

System Center Operations Manager 2007 R2 non-Windows OS Support Softpedia

Microsoft Working With Red Hat **Linux** to Increase Virtual Server Interoperability Ethio Planet News

Red Hat virtual conference announced The H

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Computerworld - Oct 12, 2009

For a brief time in 2008, **Linux** actually owned a segment of the desktop industry: netbooks. When netbooks first showed up, they ran **Linux** and nothing but **...**

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For Intel, small laptops bring challenge from ARM CNET News

ARM success could trigger takeover bid, says analyst EETimes.com

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Asus Eee PC 1008HA **Linux** source code now available

Liliputing - Oct 12, 2009

And it's currently only available with Windows XP, even though Asus was a pioneer in putting **Linux** on netbooks. But this weekend Asus did something **...**
Is **Linux** Coming To The Eee PC 1008HA? LAPTOP Magazine
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Windows/Mac/**Linux**: If you spend much time at a command/shell prompt, you're probably very comfortable navigating from one folder to the next—but rather than **...**

opensuse 11.2 RC1 Puts the 2.6.31.3 **Linux** Kernel to Work

Softpedia - Doru Barbu - 16 hours ago

While opensuse 11.2 has been in development for quite a while now, today the developer team has made available the first release **...**
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Symbian, Android will be top smartphone OSes in '12, Gartner reiterates

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Innovative Smart Home Designer Selects Wind River **Linux** for Home Automation **...**

Reuters - Oct 13, 2009

(Business Wire)-- Wind River today announced that Belgium-based fifthplay has selected Wind River **Linux** to enable its new home automation gateway. **...**

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ZDNet (blog) - Jeremy Allison - 17 hours ago

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Why Mac open source gets no respect
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Fink connects the Mac to the **Linux** open source mainstream. But most of the popular Mac open source products out there are familiar to Windows users. **...**
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October 15, 2009:JFL Peripheral Solutions has announced the availability of new **Linux** drivers, for Visioneer and Xerox DocuMate scanners. **...**

Sun adds Oracle **Linux** to ops tools
Register - Timothy Prickett Morgan - Oct 7, 2009
In addition to now being able to discover, monitor, provision, and patch Oracle Enterprise **Linux** on x64 iron, the Sun management tool can now create, **...**
JAVA

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Intel Shows Off Moblin 2.1
InformationWeek - Marin Perez - Sep 23, 2009
The chipmaker added phone and social networking functionality to its **Linux**-based operating system, paving its way into smartphones. **...**
Intel Presents the Moblin **Linux** Software for Smartphones High Tech Lounge
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The same thing happened with early netbooks and **Linux**. People didn't understand that **Linux** meant you can't just download the latest small 'windows' program **...**
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Escapist Magazine - Oct 14, 2009
All three versions of World of Goo - Windows, Mac and **Linux** - are on sale until October 19 for "whatever you think it's worth." And by all appearances, **...**
World of Goo on sale, plus iPhone version coming InfoWorld
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Linux Remote Networking Tips and Tricks
LinuxPlanet - Oct 14, 2009
Linux has all kinds of great networking abilities built-in; here are some tips and tricks for navigating multiple computers at home or in an office. **...**


Market Wire (press release)

Linux Foundation offers members @**linux**.com perk
ZDNet UK - Carly Newman - Oct 13, 2009
The **Linux** Foundation is adding to its list of membership benefits this week by offering individual members the chance to secure a lifetime @**linux**.com email **...**
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Research company Telecom Trends International says over 60% of smartphones will be running **Linux**-based operating systems by 2016 – less than a week after **...**

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Cisco becomes a major **Linux** server vendor overnight

CNET News - Matt Asay - Oct 8, 2009

If anyone needed further confirmation of Cisco's software aspirations, its forays into **Linux** offer a strong hint. In what might have looked like a publicity **...**

Cisco rewards bit twiddlers in router-to-server contest Register

Cisco routers can do more than just route... The H

Cisco Teaches Routers to Act Like Servers New York Times

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... where they've got **Linux** built in, which allows you to do software on it - they've got YouTube built in, they might have Spotify built in. **...**


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The router is built around a powerful open source **Linux** platform, giving developers and coding gurus the ability to make tweaks that would generally be **...**
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... dare to question Apple's strategy or suggest that purchasers might switch to lower-cost Windows and **Linux** machines in the midst of a deep recession. **...**
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JSTOR: The University of Chicago Law Review, Vol. 41, No. 4 (Summer, 1974), pp. 775-791

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COMMENTS

Remedies for Fraud on the Patent Office

Upon application to the Patent Office and compliance with the requirements of the Patent Act,[1] an inventor is granted[2] the right to prohibit others from manufacturing, selling, or using an invention claimed in a patent.[3] Although the Patent Office attempts to develop information relevant to each application, limited resources[4] and lack of access to relevant unpublished data force it to rely heavily on information submitted by applicants.[5] Even when disclosure is candid and complete, the Office sometimes issues patents that should not have been issued. The chances of error are obviously increased when an applicant

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1 35 U.S.C. §§ 1 *et seq.* (1970). The subject matter covered by the patent must be a "process, machine, manufacture, or composition of matter, or . . . improvement thereof," *id.* § 101, which is "new and useful," *id.*, and not obvious from the prior art in the field, *id.* § 103. The applicant must be the first inventor and must not have lost or abandoned the right to a patent, *id.* §§ 102(c), (f). The application must describe the invention in sufficient detail to enable one skilled in the relevant art to make and use the invention, *id.* § 112, and the portion of the described matter that constitutes the invention must be distinctly claimed, *id.* § 112. An applicant may appeal an initial rejection of his application through the Patent Office and, if necessary, to the courts, *id.* §§ 134, 141, 145 & 146.

2 The Patent Office usually evaluates the merits of a patent application in *ex parte* proceedings. Ladd, *Business Aggression Under the Patent System*, 26 U. CHI. L. REV. 353, 356 (1959). When it appears that two or more pending applications cover the same invention, the question of which applicant was the first inventor is decided in an adversary proceeding known as an interference. 35 U.S.C. § 135; 37 C.F.R. §§ 1.201, 1.212 (1973).

3 35 U.S.C. § 154 (1970). The grant must be temporary, U.S. CONST. art. I, § 8, and currently extends for seventeen years. 35 U.S.C. § 154 (1970). A patent holder can issue licenses under a patent or transfer all rights by assignment of the patent. *Id.* § 261; *see* Bement v. National Harrow Co., 186 U.S. 70, 88–89 (1902). Unless otherwise noted, this comment considers only original patentees. A patentee can enforce patent rights in an infringement action. The court can award various remedies: damages or treble damages for past infringement, 35 U.S.C. § 284; *see* American Safety Table Co. v. Schreiber, 415 F.2d 373 (2d Cir. 1969), *Cert. denied*, 396 U.S. 1038 (1970); an injunction against further infringement, 35 U.S.C. § 283; and, in exceptional cases, attorney's fees. *Id.* § 285.

4 The situation has not changed appreciably since Learned Hand noted: "Examiners have neither the time nor the assistance to exhaust the prior art; nothing is more common in a suit for infringement than to find that all the important references are turned up for the first time by the industry of a defendant whose interest animates his search." Rosenberg v. Groov-Pin Corp., 81 F.2d 46, 47 (2d Cir. 1936). *See generally* Graham v. John Deere Co., 383 U.S. 1, 18 (1966); Norton v. Curtiss, 433 F.2d 779, 794 (C.C.P.A. 1970); Ladd, *supra* note 2.

5 *See* Ladd, *supra* note 2, at 356–57.

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Patent application title: System, methods and apparatuses for integrated circuits for nanorobotics

Inventors: Neal Solomon
Agents: Neal Solomon
Assignees: Solomon Research LLC
Origin: OAKLAND, CA US
IPC8 Class: AG06F1750FI
USPC Class: 716 16

Abstract:

The invention describes apparatuses for nano-scale integrated circuits applied to nanorobotics. Using EDA techniques, the system develops fully functional nano ICs, including ASICs and microprocessors. Three dimensional nano ICs are disclosed for increased efficiency in nanorobotic apparatuses. Nano-scale FPGAs are disclosed. The nano-scale semiconductors have applications to nano-scale and micro-scale robots.

Claims:

1. A system for organizing a nano-scale semiconductor, comprising:a layer of hafnium substrate;a series of rows of nano-scale transistors in arrays on the substrate;routing logic arrays by using nano-scale connectors between the transistors;routing memory arrays by using nano-scale connectors between the transistors;wherein the logic arrays are structured into ASIC or MP devices;wherein the logic arrays are organized by using EDA layout software;wherein the semiconductor device has between 4,000 transistors and 20,000 transistors in a two dimensional configuration; andwherein the logic arrays contain a multiply-accumulate-convert (MAC) component.

2. The system of claim 1:wherein the device is layered with three to fifteen layers;wherein the layers are connected with through silicon vias (TSVs);wherein the layers contain tiles with specific functionality;wherein the logic arrays are structured into ASIC, MP or hybrid devices;wherein the logic arrays are organized by using EDA layout software;wherein the semiconductor device has between 20,000 transistors and 100,000 transistors in a two dimensional configuration; andwherein the logic arrays contain a multi-accumulate-convert (MAC) component.

3. The system of claim 1:wherein a series of rows of nano-scale gates are arrayed on the substrate;wherein the routing of logic arrays is done by using nano-scale connectors between the gates;wherein the gates are structured into grids of evovable logic arrays;wherein the logic array grids access look up tables (LUTs) on the periphery of the device;wherein the logic array grids access memory on the periphery of the device;wherein the gates configure to a different position when initiated;wherein the device contains between 1,000 and 10,000 gates; andwherein the device reconfigures its gates in response

to feedback from its environment.

4. A system for organizing multiple nano-scale FPGAs, comprising:a network of nano-scale FPGAs that communicate with each other by linkage in a network;wherein the network of nano-scale FPGAs coordinate their behaviors;wherein the network of nano-scale FPGAs receive inputs from an indeterministic environment;wherein the network of nano-scale FPGAs analyze the inputs fro the indeterministic environment;wherein the network of nano-scale FPGAs restructure their configurations to optimally respond to the environment; andwherein the network of nano-scale FPGAs continue to update their restructuring to the most recent environmental changes.

5. A system for organizing a nano-scale semiconductor in a nanorobotic device, comprising:a layer of hafnium substrate;a series of rows of nano-scale transistors in arrays on the substrate;routing logic arrays by using nano-scale connectors between the transistors;routing memory arrays by using nano-scale connectors between the transistors;wherein the semiconductor is installed into the nanorobotic device;wherein the semiconductor device is organized to analyze data and receive data inputs from sensors;wherein the semiconductor device is organized to send and receive signals by using a communications component; andwherein the semiconductor device activates an actuator in the nanorobot.

Description:

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001]The present application claims the benefit of priority under 35 U.S.C. § 119 from U.S. Provisional Patent Application Ser. No. 60/865,605, filed on Nov. 13, 2006 and U.S. Provisional Patent Application Ser. No. 60/912,133, filed Apr. 16, 2007, the disclosures of which are hereby incorporated by reference in their entirety for all purposes.

FIELD OF THE INVENTION

[0002]The present invention pertains to the field of nanotechnology and nanorobotics. The system deals with epigenetic robotics applied to collectives of nanorobots. Specifically, the invention relates to nanoelectromechanical systems (NEMS), microelectromechanical systems (MEMS) and nanomechatronics. The invention also deals with the coordination of collectives of nanorobots and synthetic nanorobots, including synthetic assemblies of NEMS and synthetic nano-scale and micron-scale machine assembly processes. Applications of these systems and processes are made to nanoelectronics, bionanotechnology and nanomedicine.

BACKGROUND OF THE INVENTION

[0003]To date, four waves, or generations, of nanotechnology have evolved. The first generation was comprised mainly of developments involving chemical composition, such as new nanomaterials. The second generation developed simple tubes and filaments by positioning atoms from the ground up with novel machinery. The third generation developed nanodevices that perform specific functions, such as nanoparticles for the delivery of chemicals. Finally, the fourth wave has developed self-assembling nanoentities by chemical means.

[0004]The present invention represents a fifth generation of self-organizing collectives of intelligent nanorobotics. Self-organizing processes are possible at the nano- and micron-level because of the convergence of nanoelectronics developments and nanomechatronics developments.

[0005]While the first four generations of nanotechnology have been developed by theoretical scientists and inventors, the fifth generation of nanotechnology has been largely open until now. The present invention fills the gaps in the literature and in the prior art involving nanorobotics.

[0006]Early twentieth century theoretical physicists discovered that the simplest atoms were measurable at the nanometer scale of one billionth of a meter. In 1959, in his lecture "Race to the Bottom," the physicist Richard Feynman proposed a new science and technology to manipulate molecules at the nanoscale. In the 1970s Drexler's pioneering research into nanotechnology molecular-scale machinery provides a foundation for current research. In 1979, researchers at IBM developed scanning tunneling microscopy (STM) with which they manipulated atoms to spell the letters IBM. Also in the 1970s Ratner and his team at Northwestern developed the first nano-scale transistor-like device for nanoelectronics, which was developed into nanotransistors by researchers at the University of California at Berkeley in 1997. Researchers at Rice, Yale and Penn State were able to connect blocks of nanodevices and nanowires, while researchers at Hewlett Packard and UCLA were able to develop a computer memory system based on nanoassembly. Additionally, government researchers at NASA, NIST, DARPA and Naval Research have

ongoing nanotechnology development projects, though these are mainly focused on nanoelectronics challenges. Finally, researchers at MIT, Cal Tech, USC, SUNY, Cornell, Maryland, Illinois and other universities in the U.S. have been joined by overseas researchers in developing novel nanotechnologies in order to meet Feynman's challenge.

[0007]Nanotech start-up ventures have sprung up to develop nanoscale crystals, to use as biological labels, for use in tagging proteins and nucleic acids (Quantum Dot) and to develop micro-scale arms and grippers by using MEMS to assemble manufacturing devices (Zyvex). Additionally, Nanosys, Nanometrics, Ultatech, Molecular Electronics, Applied Nanotech and Nanorex are ventures that have emerged to develop products in the nanotechnology market space. Until now, however, most of these businesses have focused son inorganic nanomaterials. Though a new generation of materials science has been aided by these earlier generations of nanotechnologies, the real breakthrough lies in identifying methods of developing intelligent systems at the nano-scale.

[0008]The two main models for building nanotechnology applications are the ground up method of building entities, on the one hand, and the bottom down method of shrinking photolithography techniques to the nanoscale. Both models present challenges for scientists.

[0009]In the case of the bottom up models, several specialized tools have been required. These include (a) atomic force microscopy (AFM), which uses electronics to measure the force exerted on a probe tip as it moves along a surface, (b) scanning tunneling microscopy (STM), which measures electrical current flowing between a scanning tip and a surface, (c) magnetic force microscopy (MFM), which uses a magnetic tip that scans a surface and (d) nanoscale synthesis (NSL), which constructs nanospheres.

[0010]In the case of the top down models, several methods and techniques have been developed, including (a) x-ray lithography, (b) ion beam lithography, (c) dip pen nanolithography (DPN), in which a "reservoir of `ink` (atoms/molecules) is stored on top of the scanning probe tip, which is manipulated across the surface, leaving lines and patterns behind" (Ratner, 2003) and (d) micro-imprint lithography (MIL), which emulates a rubber stamp. Lithography techniques generally require the creation of a mask of a main model, which is then reproduced onto a substrate much like a semiconductor is manufactured. It is primarily through lithographic techniques that mass quantities of nanoentities can be created efficiently and cost-effectively.

[0011]The main patents obtained in the U.S. in the field of nanotechnology have focused on nanomaterials, MEMS, micro-pumps, micro-sensors, micro-voltaics, lithography, genetic microarray analysis and nano-drug delivery. Examples of these include a meso-microelectromechanical system package (U.S. Pat. No. 6,859,119), micro-opto-electro-mechanical systems (MOEMS) (U.S. Pat. No. 6,580,858), ion beam lithography system (U.S. Pat. No. 6,924,493), carbon nanotube sensors (U.S. Pat. No. 7,013,708) and microfabricated elastomeric valve and pump systems (U.S. Pat. Nos. 6,899,137 and 6,929,030). Finally, patents for a drug targeting system (U.S. Pat. No. 7,025,991) and for a design of artificial genes for use as controls in gene expression analytical system (U.S. Pat. No. 6,943,242), used for a DNA microarray, are applied to biotechnology. For the most part, these patents represent third and fourth generation nanotechnologies.

[0012]A new generation of nanotechnologies presents procedures for objects to interact with their environment and solve critical problems on the nano- and micron-scale. This generation of technology involves social intelligence and self-organization capabilities.

[0013]Biological analogies help to explain the performance of intelligent or self-organizing nanoentities. In the macro-scale environment, the behaviors of insects provides an important model for understanding how to develop models that emulate social intelligence in which chemical markers (pheromones) are used by individual entities to communicate a social goal. On the micro-scale, microbes and pathogens interoperate with the animal's immune system, in which battles either won or lost determine survival of the host. Other intracellular models show how proteins interact in order to perform a host of functions. At the level of DNA, RNA transcription processes are highly organized methods for developing cellular reproduction. These micromachinery processes and functions occur at the nanoscale and provide useful analogies for nanotechnologies.

[0014]In order to draw on these biological system analogies, complexity theory has been developed in recent years. Researchers associated with the Sante Fe Institute have developed a range of theoretical models to merge complexity theory and biologically-inspired processes, including genetic algorithms and collective behavior of economic agents.

[0015]Such a new nanotechnology requires distributed computation and communication techniques. It is, moreover, necessary for such a technology to adapt to feedback from its environment. The present invention presents a system in which these operations occur and specifies a range of important applications for electronics, medicine and numerous other areas. The main challenges to this advanced nanotechnology system lie in the discovery of solutions to the problems of limited information, computation, memory, communication,

mobility and power.

[0016]Challenges

[0017]The development of a fifth generation of nanotechnologies faces several challenges. First, the manufacturing of nanoparts is difficult. Second, the assembly of nanoparts into functional devices is a major challenge. Third, the control and management of nanosystems is complex. Since physical properties operate differently at the nano-scale than at the macro-scale, we need to design systems that accommodate these unique physical forces.

[0018]The problems to identify include how to: **[0019]**Build nanorobots **[0020]**Connect nanodevices **[0021]**Develop a nanorobotic power source **[0022]**Develop nanorobotic computation **[0023]**Develop specific nanorobotic functionality **[0024]**Develop nanorobotic communication system(s) **[0025]**Develop multi-functional nanorobotics **[0026]**Activate nanorobotic functionality **[0027]**Develop nanorobotic computer programming **[0028]** Develop an external tracking procedure for a nanorobot **[0029]**Develop an external activation of a nanorobot **[0030]**Develop a hybrid control system for nanorobots **[0031]**Use AI for nanorobots **[0032]**Obtain environmental inputs via sensors

[0033]Developing Solutions to these Problems

[0034]Most prior technological innovations for nano-scale problems have focused on the first generations of nanotechnology and on materials science. The next generation focuses on intelligent systems applied to the nano entities. This fifth generation of innovation combines the development of nano-scale entities with intelligence of complex systems.

[0035]Few researchers have devised solutions to these complex nano-scale problems. Cavalcanti has developed theoretical notions to develop a model of nanorobotics. However, these solutions are not practical and will not work in real situations. For example, there is not enough power of mobility in this model to overcome natural forces. Similarly, according to this theoretical approach, autonomous computation resources of nanorobots are insufficient to perform even the simplest functions, such as targeting. Without computation capacity, AI will not work at this level; without AI there is no possible way to perform real-time environmental reaction and interaction.

[0036]Cavalcanti's 2D and 3D simulations are dependent on only several variable assumptions and will not withstand the "chaos" of real environmental interactive processes. In addition, the structure of these nanorobots cannot be built efficiently from the bottom up and still retain critical functionality. Even if these many problems can be solved, individual nanorobots cannot be trusted to behave without error inside cells.

[0037]The emerging field of epigenetic robotics deals with the relations between a robot and its environment. This field suggests that it is useful to program a robot to learn autonomously by interacting with its environment. However, these models do not apply to groups of robots in which it is necessary to learn from and interact with many more variables in the robots' environment, including societies of other robots. In the case of groups of nanorobots with resource constraints, the present invention adds volumes to this promising field.

[0038]Solomon's research in developing hybrid control systems for robotic systems and in developing novel approaches for molecular modeling systems presents pathways to solving these complex problems. These novel research streams are used in the present invention.

[0039]Prior systems of robotics generally do not address the complexities of nanotechnology. The behavior-based robot system using subsumption methods developed by Brooks at MIT is useful for managing individual robot behavior with limited computation capacity. On the other end of the spectrum, central control robotic systems require substantial computation resources. Hybrid control robotic systems synthesize elements from these two main control processes. Even more advanced robotic control systems involve the integration of a multi-agent software system with a robotic system that is particularly useful in controlling groups of robots. This advanced robotic control system experiences both the benefits and detriments of the behavior-based model and the central control model.

[0040]The Nanorobotic Environment

[0041]The nano domain, which is a billionth of a meter, is measured in millionths of a meter. A single oxygen atom is roughly a single nanometer across. A micron is a millionth of a meter. The width of a human hair is about 60,000 nanometers.

[0042]The present invention focuses on the synthetic development of objects that are in a middle (meso-nano) sphere somewhat between the atomic size (micro-nano) of simple atoms and the mega-nano domain of micron-sized objects. While it is true that scientists have built, from the ground up, that is, atom by atom, objects such as elegant geodesic

nanotubes made of carbon atoms, objects in this domain are too small and too expensive to construct to be useful for an active intelligent system. In order to be useful, a nanorobotic system requires numerous and economical robots dependent on mass production techniques that must generally be considered from the perspective of a top down strategy, that is, by utilization of largely lithographic procedures.

[0043]The nanorobotic entities described herein generally consist of objects with dimensions from 100 nm to 1000 nm (1 micron) cubed, but can be smaller than 100 nm or larger than ten microns. This size is relatively large by nanotechnology standards, but is crucial in order to maintain functionality. Keep in mind that a white blood cell is comprised of about 100,000 molecules and fits into this meso-nano domain. The micron-scale space of inter-object interaction may be comprehended by analogy to a warehouse in which nanoscale objects interact. In order to be useful, nanorobots require complex apparatus that includes computation, communications, sensors, actuators, power source and specific functionality, all of which apparatus requires spatial extension. Though this domain specification is larger than some of the atomic-scale research in nanotechnology, it is far smaller than most microelectronics.

[0044]While the larger meso-nano assemblies described herein possess a specific geometric dimensionality, the size dimensions of the domains in which they operate are also critical to consider. In these cases, each application has a different set of specifications. In the case of the human body, specific cells will have a dimensionality that is substantially larger than the complex molecular-size proteins that are constructed for interoperation within them.

[0045]Over time, however, it will be possible to make very small, useful micro-nano scale robots for use in intelligent systems. Thus, we may conceive of several generations of scale for these systems, the first being in the meso-nano domain.

SUMMARY OF THE INVENTION

[0046]The invention specifies nano-scale integrated circuits (ICs) with applications to nanorobotic electromechanical devices. The nano-ICs have microprocessor, ASIC or FPGA architectures. The IC architectures include computer memory, MAC components and interconnects that are designed with EDA software. The system also specifies nano-scale system on chip architectures.

[0047]The invention disclosed a class of nano-scale three dimensional ICs. By stacking layers of ICs onto 3D chips using through silicon vias (TSVs) and multilayer CMOS fabrication techniques, the nano-MPs, nano-ASICs and nano-FPGAs of the present invention maximize performance and efficiency.

[0048]The chips are applied to nanorobotics. By integrating nano-scale ICs into nanorobots, the nanorobot devices obtain intelligence functionality that includes data analysis, memory access, sensor access, communications control and mobile control.

[0049]The ICs process program code by employing software agents and by interacting with external computation. Specifically, the system uses genetic algorithms and reduced instruction AI techniques to overcome computing resource constraints.

[0050]The present system is also applied to microrobots and to devices that integrate MEMS.

[0051]Advantages of the Invention

[0052]Use of nano-scale ICs provide intelligence functionality to nanorobots and microrobots.

[0053]By combining multiple nanorobots into collectives, the use of nano-scale ICs allow grid computing capabilities that allow social intelligence capabilities with numerous applications to electronics and biology.

DESCRIPTION OF THE INVENTION

[0054](I) Integrated Circuits in Nano-Robots

[0055]In order to achieve intelligence, it is necessary for nano-scale and micron-scale robotic entities to embody integrated circuits. While trends in ICs have focused on generating the fastest chips with billions of transistors, the current system seeks to develop extremely small, yet highly functional, circuits for use in nanorobots. By interoperating with multiple nanorobots, the intelligent robots are organized into collectives similar to the grid computing paradigm.

[0056]One main model for nanorobotic ICs is the traditional two dimensional chip approach which employs microprocessor architectures, such as RISC, ASIC and complex

programmable logic device (CPLD), such as FPGA architectures. This model integrates logic and memory components using traditional interconnects onto devices in different chip configurations according to each application preference.

[0057]Another model employs a new generation of efficient three dimensional IC architectures. This approach stacks layers of ICs by using through silicon vias (TSVs) to connect the layers. This model is useful to create micron-scale and nano-scale 3D system on chip (SoC) technologies that are applicable to nanorobotics. This approach leads to the system on a nano chip (SONC) model disclosed herein.

[0058]Because the model employs multiple nanorobots in collectives in order to be functionally useful, the present invention uses heterogeneous computing options to maximize functionality. For example, collectives of nanorobots are comprised of nanorobots that include multiple types of ICs, including ASICs, MPs, FPGAs and active storage devices that integrate logic and memory in different ways in order to optimize specific tasks. By working together in collectives using a division of labor enabled by multiple computing types, the present system maximizes computability at the ultra small scale.

[0059]Micron-scale computing exists. Hitachi has produced a family of micron-scale chips that measure 0.4 mm squared. The "super-micro" chips are used for radio frequency identification (RFID) applications. Since they contain read only memory exclusively, their functionality is highly restricted.

[0060]However, with the advent of smaller transistors made possible by novel lithographic techniques, next generation ICs will be capable of very small size. In a sense, rather than seeking ever faster computing capability with more and more transistors in order to maintain Moore's law, the present system seeks to go back to the origins of the integrated circuit.

[0061]The first microprocessors, such as the Intel 8080, used only 4500 transistors and were capable of 200K operations per second. The Motorola MC6800 used 200K transistors and achieved substantial functionality.

[0062]The present system is able to achieve capabilities between 4,000 and 1,000,000 transistors within nano-scale and micron-scale integrated circuits, respectively, in both 2D and 3D embodiments, in order to be useful within nanorobots and micron-scale robots.

[0063]While 45 nm transistors are used in ICs, 32 nm, 26 nm, 22 nm, 16 nm and 10 nm scale transistors have been constructed using novel lithographic techniques. For 22 nm transistors high index immersion lithography is used and for 16 nm transistors high index immersion lithography is combined with double patterning techniques. 10 nm and 16 nm transistors are comprised of 3D fin field effect transistors (FETS). These classes of ICs are designed using CMOS fabrication techniques.

[0064](1) Nano-scale Integrated Circuit for Nanorobots using EDA Processes

[0065]Electronic design automation (EDA) techniques are used in the chip architectural process. Transistors are organized in logic and memory components of integrated circuits by using layout and routing of interconnects with EDA.

[0066]Nano-scale ICs are designed as simple modular combinations of logic and memory components. By organizing a family of N-ICs, EDA techniques develop optimal options with 4,000 to 10,000 transistors. These small chip options, whether ASIC, FPGA microprocessor or hybrid, deliver multiple functionality for nanorobots. Very simple MP functionality is supplemented by combining multiple nanorobots into collectives that share computation, communications and software.

[0067]Chips at the submicron scale are designed in CMOS by using lithographic fabrication techniques. The 2D model N-IC results in "flat" chips that are useful in some nanorobotic applications, particularly for the simplest computational functions.

[0068]These chips contain 16-bit or 32-bit RAM and 256-byte or 512-byte ROM memory components and are capable of 8-bit, 16-bit or 32-bit computation functionality.

[0069]Because they are SoNCs, they also contain analog functionality (ADC and DAC), sensors and communications functionality on the chip as well as logic and memory capability.

[0070](2) Three Dimensional Nano-IC for Nanorobots

[0071]Three dimensional ICs possess increased functionality in an efficient space than traditional 2D ICs. 3D chips stack 2D layers of ICs and are constructed using CMOS layering techniques in fabrication. The 3D chip architecture allows organization of memory and logic on tiles of each layer and thereby increases the options for chip design in order to optimize chips for multiple applications. These hybrid N-ICs provide an ideal application to

nanorobotics.

[0072]By constructing a layer of a 3D N-IC with 26 transistors by 26 transistors, or 676 transistors on a single layer, and by stacking eight layers using CMOS technology, the 3D N-IC are comprised of a total of 5408 transistors, yet are contained in a compact space with an 4:1 aspect ratio. Only a small deviation of one less transistor per row yields a 25 by 25 transistor layer (525 transistors on a single layer) and 4200 transistors on an 8 layer N-IC.

[0073]In substantially larger 3D N-IC chips, 200 transistors by 200 transistors comprise a single layer of 40K transistors, with a total of 200K transistors in a 5 layer N-IC. With an average transistor size of 22 nm (averaging 16 nm and 26 nm), the total space used is approximately 4400 nm squared (19,360,000 nm square). This chip is capable of 6 MIPS. Similarly, using 100 by 100 transistors yields a 10,000 transistor layer. Nine layers of this chip produces a 90K transistor 3D N-IC capable of 3.6 MIPS. This chip is approximately 2200 nm squared (4,840,000 nm square). Finally, 258 by 258 transistors produces 66,666 transistors per layer. Stacking 12 layers produces an 800K transistor meso N-IC device capable of 24 MIPS.

[0074]3D N-ICs may be MPs, ASICs, FPGAs, active storage devices or hybrids.

[0075](II) Nano-scale FPGAs

[0076]Field programmable gate arrays (FPGAs) are either deterministic or indeterministic. Deterministic FPGAs are used to oscillate between various application specific integrated circuit positions in order to adapt to a changing environment. Indeterministic FPGAs will operate continuously until they solve a particular problem. These continuously programmable FPGAs (CP-FPGAs) are used for rapid prototyping in the field thereby enabling them to interact with an evolving environment.

[0077](1) Nano-FPGAs (N-FPGAs)

[0078]Given the steady increase in semiconductor speed and steady decrease in size, the design of nano-scale FPGAs is achievable.

[0079]The present invention specifies an FPGA in which there is continuous transformation of the configuration of the gate arrays in order to solve problems at the nano-scale. Among other applications, N-FPGAs will be used within nano-robots in order to more rapidly interact with an evolving environment. While N-FPGAs are used within the nanorobots to provide computational functionality, the gates of the N-FPGAs are comprised of nano-scale objects and interconnects.

[0080]Since the N-FPGA is indeterministic in order to maintain maximum functionality in evolutionary environments, it is necessary to have a way to track the record of its evolution. The present system therefore has a mechanism to track the evolvability pattern of the N-FPGA in order to record its transformational pathways by exporting its sequential evolution of structural transformation to an external computer for analysis. This method of tracking the indeterministic N-FPGA, by using communications links and modeling processes, eliminates the need to reverse-engineer the specific pattern of the evolution of the gate structures over time. By creating a communications interface that tracks the gate structure evolution process using an external computer, the system provides additional environmental data and activates the N-FPGA by employing external macro-computation as well.

[0081](2) Evolutionary N-FPGAs

[0082]Because they are comprised of nano-scale parts, N-FPGAs "evolve" on-demand by combining autonomous programmable modular components and logic arrays in order to expand functionality. For example, this autonomous modularity of components facilitates whole memory sections of a chip while the chip is operational. This allows a new dimension of nano-scale evolvable hardware (N-EHW) in which whole new sections of the chip autonomously evolve. This embodiment of the present invention is critical in order to establish self-repairing hardware on the nano- and micron-scale. With this process it is possible to engage in the limited replication of a semiconductor in the field, for the purpose of repairing hardware. This view presents an embryonic model of electronics N-EHW. The development of a micro-scale artificial brain is a consequence of this view of evolutionary semiconductors.

[0083]By using the N-EHW CNR features of self-assembly and reaggregation, the present invention provides methods for FPGAs' to add sections and functional capacity akin to an evolving artificial brain. This would be similar to the development of a brain from a child to that of an adult in which the modular aggregated N-FPGA network co-adapts to its evolving environment and constantly learns as it grows in order to continually optimize its performance.

[0084](3) Networks of N-FPGAs

[0085]Networks of N-FPGAs operate within a CNR system. The N-FPGAs have external linkages between nanorobot nodes. The N-FPGAs are the artificial brains of the nanorobots and are linked together into a network by a communications system that uses software agents in a multi-agent system. In networks of N-FPGAs in CNRs, the nanorobots that are not functional represent bottlenecks around which the network reroutes communications. The N-FPGA and CNR network achieves a level of operational plasticity by constantly rerouting its arrangement in order to optimize solutions.

[0086]By linking together the N-FPGAs into a computer network, the computational capacity of the CNR system substantially increased.

[0087]In another embodiment of the present system, N-FPGAs are not contained within the nanorobots, but rather function as central modules CNRs may access. These micro-FPGAs are centralized for use by a single CNR team or a combination of teams. These FPGAs behave as the main computer server for the multitude of nanorobots in the collective. The FPGAs appear as centralized modules that are physically adjacent to the CNR teams.

[0088]In yet another embodiment of the system, micro- or nano-FPGAs are replaced by micron- or nano-scale microprocessors.

[0089]In still another embodiment of the invention, the system uses external computing resources that are accessed through the communication system by the use of software agents.

[0090](4) Interaction of N-EHW CNRs and N-FPGAs

[0091]One of the main advantages of utilizing FPGAs is to adapt the hardware to an environment based on feedback from the environment as it changes. Similarly, the advantage of the N-EHW is to adapt to feedback from an evolving environment.

[0092]The feedback from, and adaptation to, the environmental changes activate the transformational processes of both the N-FPGAs and the N-EHWs. The new position of the N-EHW apparatus then transforms its configuration and accepts new information from the environment and continues to transform in new ways to adapt to the changing environment and so on. The next stage input of the environment will then stimulate the N-FPGA transformation, which will then respond to the environmental change, which, in turn, will stimulate a transformation in the structural configuration of the N-EHW apparatus. This process of co-evolutionary transformation will continue to oscillate for numerous phases.

[0093]These co-evolutionary and adaptive processes will continue until optimal solutions are achieved. These complex dynamics of the N-EHW and N-FPGA systems will solve key molecular biology problems.

[0094]As the functional utility of the N-EHW operates in the environment, the structural apparatus of the N-EHW system will act upon and change the environment. The rate of change in the environment will therefore be reduced as the N-EHW performs its function, and thus the N-EHW and the N-FPGA interactions will achieve a relative position of equilibrium in the self-organizing and self-assembling systems.

[0095]Reference to the remaining portions of the specification, including the drawings and claims, will realize other features and advantages of the present invention. Further features and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with respect to accompanying drawings.

[0096]It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and scope of the appended claims. All publications, patents, and patent applications cited herein are hereby incorporated by reference for all purposes in their entirety.

DESCRIPTION OF THE DRAWINGS

[0097]FIG. 1 is a schematic diagram of a nano-scale integrated circuit.

[0098]FIG. 2 is a schematic diagram of an integrated circuit illustrating main sections.

[0099]FIG. 3 is a schematic diagram of a three dimensional nano-scale integrated circuit.

[0100]FIG. 4 is a diagram of a top view of the tiles of a nano-scale FPGA.

[0101]FIG. 5 is a schematic diagram of a four layer three dimensional nano-scale IC with fifteen sections on each layer.

[0102]FIG. 6 is a set of diagrams illustrating the sequence of an evolvable logic array.

[0103]FIG. 7 is a schematic diagram of a top view of a grid of evolvable logic gates shifting positions in a process of evolution.

[0104]FIG. 8 is a schematic diagram of a top view of an evolvable logic array illustrating the transformed position of the specific logic gates.

[0105]FIG. 9 is a schematic drawing of the top view of four layers of evolvable logic arrays in different positions.

[0106]FIG. 10 is a schematic drawing of the top view of an FPGA layer of an IC in the context of interaction with environmental change.

[0107]FIG. 11 is a flow chart showing the process of analyzing sensor data by an FPGA.

[0108]FIG. 12 is a flow chart showing the processing of an FPGA.

DETAILED DESCRIPTION OF THE DRAWINGS

[0109]In order for nanorobots to have functionality, they require intelligence made possible by integrated circuitry. The three main models for semiconductors are application specific integrated circuits (ASICs), microprocessors (MPs) and complex programmable logic devices (CPLDs), the most prominent of which are field programmable gate arrays (FPGAs).

[0110]While most electronics IC components have grown to include billions of transistors, made possible by lithographic fabrication techniques to shrink the size of transistors, the present invention uses the development of nano-scale transistors to produce small nano-scale ICs. These minimalist ICs perform specific functionality associated with the first generation of useful MPs and ASICs, yet are in a tiny package that is integrated into nanorobotic apparatuses.

[0111]In addition to traditional two dimensional IC development, the present system also integrates the development of three dimensional ICs, which are more efficient and space saving than 2D components.

[0112]FIG. 1 illustrates the top view of a three dimensional nano-scale IC (100) which has a section for ROM (110) and RAM (120). The lines illustrate rows of transistors.

[0113]In FIG. 2, a top view of an IC (200) is illustrated with an emphasis on showing the sections of the layer of the IC. The RAM component (210) is shown and the multiply accumulate convert (MAC) component (220) is shown in differentiated sections.

[0114]FIG. 3 shows a three dimensional IC (300) with fourteen layers (310). 3D ICs provide a way to combine multiple layers for increased functional efficiency.

[0115]FIG. 4 shows a top view of the tiles on an FPGA layer (400). The outer layer shows 16 tiles (410) on which look up tables (LUTs) and ROM components are situated. The inner layer has 20 tiles (420) on which logic arrays are situated. The logic arrays have gates that change position to transform from one ASIC position to another in order to solve computational problems.

[0116]FIG. 5 shows an IC (500) comprised of a stack of four layers (510), with fifteen tiles on each layer (520).

[0117]FIGS. 6, 7 and 8 show the changed positions of the FPGA. FIG. 6 shows three main positions (A, B and C) illustrating the alternating positions of an evolvable logic array from position at 600 to position 610 to position 620. FIG. 7 shows the different positions of each layer (1 through 6 at 710 through 760) of a six layer FPGA (700). FIG. 8 shows a top view of a conversion process of a layer of an FPGA (800) as its logic array gates change from one position to another. In this dynamic sequence, the logic array gates continue to change their positions until they achieve the ASIC position. In some embodiments, this process of changing the position of gate arrays to various ASIC positions will continue until a computational problem is solved. In one view, this representation shows the cross section of the changing of a cellular automata process with each symbol referring to a temporary state feature (810, 820 and 830).

[0118]FIG. 9 illustrates the connection between four FPGAs (910, 920, 930 and 940) which are shown in different simultaneous positions.

[0119]FIG. 10 shows a top view of an FPGA layer (1000) with a reference to the changing environment. The FPGA will change positions in reaction to the changed inputs from the changing environment. At A (1010), an initial position will begin the process of changing the position state of the FPGA. As the environment changes (1050), the position B (1020) will alter the position of the gate array in the FPGA. This process continues as the environment

continues to change at C (1030) and D (1040). The changing of the positions of the FPGA gate arrays effectively reprograms the IC. As the chip is reprogrammed, it performs a new set of functions that interact with the environment. This interaction process provides a feedback loop.

[0120]FIG. 11 shows a flow chart which describes the initial process of repositioning the FPGA. After the power supply activates the IC (1100), software is loaded to ROM (1110) and sensors provide data inputs to the IC (1120). Data is transferred to the database in RAM (1130) and sensor data is analyzed by the IC (1140). Finally, the IC performs a function once activated by accessing the RAM (1150).

[0121]In FIG. 12, the process of FPGA operation is shown. Once the FPGA is activated (1200), software is loaded onto the look up tables (1210) and the logic array gates are activated (1220). Data is input to the FPGA (1230) and the FPGA processes the data in an initial position (1240). New data is input into the FPGA that requires a change of gate positions (1250) and the logic array gates move from position A to position B in a sequential process (1260). The process then repeats as new information is made available, which stimulates a transformation of the logic array gate positions. This process repeats until a specific problem is solved.

Patents by Neal Solomon

Patents by Solomon Research LLC

Patents in class PLA, PLD, FPGA, OR MCM

Patents in all subclasses PLA, PLD, FPGA, OR MCM

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Patent Investment Trusts: Let's Build a PIT to Catch the Patent Trolls

Elizabeth D. Ferrill[1]

troll (trōl) *n.* In Norse Mythology, repulsive dwarfs who lived in caves or other hidden places. They would steal children and property but hated noise.[2]

I. Introduction

Peter Detkin, the assistant general counsel for Intel, coined the term "patent trolls" in the late 1990s, to describe his own impression of this new legal dwarf.[3] According to Detkin, a patent troll is "somebody who tries to make a lot of money off a patent that they are not practicing and have no intention of practicing and in most cases never practiced."[4] In a business that collects more than $100 billion annually in licensing fees,[5] these patent trolls are taking an ever increasing piece of the licensing pie for themselves,[6] much to the chagrin of their prey.

[1] J.D. Candidate, University of North Carolina School of Law, 2006. Special thanks to Frank DeCosta, of Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P. for his assistance.
[2] E.D. HIRSCH, JR. ET AL., THE NEW DICTIONARY OF CULTURAL LITERACY 45 (2002). "The troll in the children's story 'The Three Billy Goats Gruff,' for example, lives under a bridge and is enraged when he hears the goats crossing the bridge." *Id.*
[3] Brenda Sandburg, *Inventor's Lawyer Makes a Pile from Patents*, THE RECORDER, July 30, 2001, LEXIS, Nexis Library, RECRDR File.
[4] *Id.*
[5] Andrew Carter & Fayth A. Bloomer, *Generating Cash from a Patent Portfolio: An Overview*, PAT. STRATEGY & MGMT., Aug. 6, 2004 at 5.
[6] Alexandra Dell, *Just Can't Get Enough*, INTELL. PROP. L. & BUS., July 2004, *available at* http://www.ipww.com/texts/0704/acadiz0704.html (citing that Acacia Research Corporation's 2004 earnings are projected to be $2.5 million, up from $599,000 in 2003).

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October 18 – 20, 2006, Belgrade, SASA, Serbia

How were Patent Rights from Nikola Tesla Stolen

Milan Božić[1]

Abstract –**On the occasion of marking the commencement of works at Niagara Falls on 12th January 1897, talking about the monuments left by the inventors to the civilization, Tesla said "We have numerous monuments of past times, we have castles, palaces, Greek temples and cathedrals. They reflect the strength of people, the greatness of a nation, the love towards art and dedication to religion. This monument at Niagara denotes the beginning of harnessing the forces of nature to human needs and the salvage for millions of people. Regardless of all our endeavours we still depend on the inventors. Our economists may propose more efficient management methods, our lawyers may create wiser laws, but without the inventors we can not live better lives. To reduce poverty we need more inventions. With sufficient inventions at disposal we can fulfil lots of wishes and provide guarantees for a safe and comfortable life to all, save for, perhaps, those who are the greatest of all villains – the ignorant and idlers. Development and wealth of peoples and progress of the entire human race depend on the number of inventions".**

Keywords –**Nikola Tesla, Niagara Falls, Patent.**

I. INTRODUCTION

Number of inventions – the basic impulse which prompts material development of mankind is created by inventive people. They are spiritual people – inventors, as Mihajlo Pupin put it – who is not guided by greed for money, but by care that material progress is everywhere accompanied by spiritual growth, thus expelling greed and hatred from the human heart by applying the most powerful spiritual force – the power of love, in the way the Christian philosophy also pleads for. Therefore, inventions are not merely economic, but also a human and spiritual category.

The inventions originate from the earliest period of human existence and the idea of protection and fair reward of their authors date back to the period of Ancient Greece, the age of Pythagoras. In Europe greater attention to inventions was devoted in the Middle Ages (XIV and XV century), when inventors were given various privileges. Frequently the kings granted such privileges for new products and innovations that stimulated economic development. In addition to the exclusive right of the inventor to manufacture his invention, the privileges implied protection of the privilege holder from powerful guild organizations. At that time, the entire economy was organized by guilds and there were no free economic activities out of control of such organizations. The guilds were particularly unfriendly towards inventors among their members because they feared from disruption in the strict system of internal relations. Contrary to them, the wise kings invited craftsmen (not only from their countries) to apply their knowledge in the advancement of production of material value, whereby they protected them by privileges. It is found in literature that the first privileges were known about 500 B.C. in the Greek colony Sibaris, in the south of Italy. There was a privilege given to a cook who invented a new recipe for preparation of a dish that meant his exclusive right to prepare such dish for the period of one year. Let us mention here the Venetian Decree from the year 1474**,** which is also known as the Venetian Law, although it is not what it is (because the authorities decide whom the privilege is to be granted to). This assertion is supported by the application of Galileo Galilei from the year 1594, who requested the privilege for his invention "device for water transport" from the Venetian authorities. We will also mention the privilege that was granted to Pascal in the year 1649 for the invention of the calculating machine and the privilege to Higgens for the clock mechanism. Still, the famous English Statute on Monopolies from 1623 passed by the King Jacob Stuart I can be considered to be the first patent law. This Statute proclaims all monopolies illegal, excluding the ones resulting from the inventions. England, France, USA and Germany were the leading counties in the field of patent law from the fifteenth to nineteenth century and establishment of the International Patent System in 1883 or Paris Convention. At the time of the King Milan's rule Serbia was one of the 11 founding countries of this Convention. The first modern patent law based on the ideas of the French Revolution was first adopted in USA in 1790, and then in France in 1791; Brazil, 1809; Austria, 1810; Russia, 1812; Prussia, 1817; Belgium, 1820; Spain, 1825; Mexico, 1836; Chile, 1840, Portugal, 1852; England, 1852; Italy, 1859, India, 1859, and other countries. In Yugoslavia such law was passed only in 1922.

II. PARIS CONVENTION

Paris Convention represents international basis for the national patent systems and covers the markets in the

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[1]Milan Božić Patent Engineer

countries where the patents could be potentially applied, retaining monopoly in production.

It was signed in 1883 by 11 countries, and negotiated between Belgium, France, Great Britain, Italy, the Netherlands, Portugal, Serbia, Spain and Switzerland from Europe; Brazil, Ecuador, Guatemala and El Salvador from Latin America and Tunisia from the Northern Africa. USA joined in 1887.

From the very beginning the Paris Convention has been a privilege of the rich. It was revised 6 times: Brussels, 1900; Washington, 1911; the Hague, 1925; London, 1934; Lisbon, 1958; and Stockholm, 1967. In addition to these six successful diplomatic conferences the other two were in Roma in 1886 and in Madrid in 1890. Each of these revisions affirmed monopolistic right of the foreign patentees, making their market function stronger. The main conflict of interests of the foreign patentees from the technologically developed countries and the public interest of the developing countries has been interweaving in this Convention.

The developing countries have been fighting against this, especially after the World War II in order to redefine the whole system of the industrial property, with fairer relations, both on the national and international level. Unfortunately, it all came to nothing because at the end of the twentieth century someone had an idea to transfer the patent system from UNCTAD (specialized UN organization for trade and development) to GATT – "the club of the rich" (General Agreement on Tariffs and Trade), and thus weaken manufacturing role of the patent at the expense of the poor countries.

Some of the essential articles of the Convention are briefly given in the further text. The first Article deals with definition of scope and contents of the industrial property. The second Article guarantees equal treatment of patents from all countries, rich or poor, weak or strong, developed or undeveloped. This apparent equality between the very strong and the very weak is a continuous advantage of the powerful companies from the developed countries on the underdeveloped markets.

The Convention states in details the manner in which the signatory countries should adopt new and abolish the current laws in order to respond to the main purpose of the Convention – to protect only the rights of the patentees, but totally neglecting their obligations.

Article five represents a historical compromise between the conflicting interests of the patentees and the public interests. It treats a key issue of approval for the use of the granted patent – whether it is really used in the country granting the patent right or not. In this way it becomes legitimate that importation of articles manufactured in any of the countries of the Union by the patentee into the country where the patent has been granted shall not entail forfeiture of the patent. The Article 5A strictly limits a compulsory license by setting very severe preconditions. As a consequence of that and the insufficient knowledge about the importance of this license it took more than 100 years of struggle to get only 20 favourable legal decisions which protect the public interest. In Canada, where this problem draws much greater attention, such compulsory license often protects public interests.

However, there is an aspect deserving special attention. The Convention could become acceptable provided major compromise is made between the private interests of the patentees and the public interests. To that end, it would have to acknowledge the main freedom and flexibility of the member countries to make their own regulations in accordance with the way they understand their own national interest and the degree of their economic development.

The Convention has a unique system as indicated by the provision concerning its revision requesting unanimous consent. Veto system, limited to only five UN Security Council members, is only pale reflection of the practice introduced in the Paris Convention much earlier. Even the procedure of withdrawal from Convention is rather complicated and time consuming. It can last five to six years.

Had the Paris Convention (international patent system) been intended to protect the inventors from its very beginning, which is one of its main tasks, Nikola Tesla could have not been robbed. To date, it has unfortunately been protecting only the powerful transnational companies in their greed, or the powerful states to the disadvantage of the weaker inventors in protecting their rights and the spiritual values.

III. Patents Decisive for Stages in Industrial Development

A patent is not only an economic, but also a human institute. Partly it protects inventors, but it is more a driving force of the industrial revolution. The three patents determined the First, Second and Third Industrial Revolutions.

Some people think that industrial revolution did not begin with the invention of the steam engine, but with the invention of the water-mill. All main characteristics of the industry powered by the force of water that existed in the Roman Age are the heritage of the Hellenic World. The medieval Christianity was the first civilization to know how to use the machines for different needs. The water-mill was also used for some other purposes: driving of the rollers, crushers, coal milling, olive squeezing, fruit pressing, etc. However, a big disadvantage of the water-mill is fixed location of the water power, as well as of the power of wind. At that time, there was no known way to transmit this energy to the other location for use. That was achievable by means of the electric power only at the end of the nineteenth century, with the appearance of a large number of inventions created by Faraday, Gramme, Swan, Jablokov, Edison, Tesla and others.

Still the world counts the First Industrial Revolution from 1769, when James Watt patented the first steam engine. He solved the technical problem of translation of straight line piston movement into the rotary motion of the flywheel. He invented the automatic distributor and capacitor and used steam expansion on both sides of the piston. In this way he created the practical machine which was the only driving unit in the factories, mines, mills, textile and other factories for more than one century, until the end of the nineteenth century.

In the field of electricity, the nineteenth century gives birth to a large number of the significant inventions that enabled the Second Industrial Revolution which begins with Tesla's patents. Great English scientist and inventors Faraday

and Maxwel can be mentioned here. The first invented electromagnetic induction in 1831 and enabled production of electric energy in dynamo-engine. The second invented magnetic flux and the way it transmits its energy through space. Faraday invented electric motor and thus helped Morze to invent electric telegraph in 1837, Reis and Bell to invent the telephone, the former in 1861, and the latter in 1876, Mihajlo Pupin to invent long distance voice transmission and Gramme to invent a practical dynamo-engine and electric motor in 1868. The Belgian Gramme made a great achievement and the true electrical engineering begins with this invention. The Gramme's machine made it possible for the great Russian inventor Jablokov in 1876 to invent electrical lighting by using his invention of arc lamp, and for Edison and Swan in 1879 to invent electric bulb, which was greatly facilitated by the scientific research work of the Russian scientist Ladigin. Jablokov is the inventor of the transformer which converts alternating current of certain voltage into some other voltage. This transformer was patented in England in 1877, and Jablokov was considered to be an inventor of electric lighting.

In the nineteenth century Europe started to integrate science and technology aiming at application of the scientific results in industry through the epochal inventions. The process started in Germany in 1887 when Siemens founded the Technical Institute for Experimental Research where Hemholz, Herz, Kirchhoff, Plank and many others, including our scientist Mihajlo Pupin, worked.

In the second half of the twentieth century Intel microprocessor (USA, 1971) invented by Ted Hof, an engineer, started the **Third Industrial Revolution**, which opposite to the first two industrial revolutions that found substitute for the physical labour, provides machines that can even replace the human brain.

IV. INNOVATION MOVEMENTS

Prevalence of the philosophical learning of Democritus – Archimedes – Bacon – Newton created the preconditions for the development of the Innovation Movement in some countries. It originally started in the European countries in the seventeenth century and later on, first in England, Germany, France and other countries in the eighteenth century the real inventor movement was active. In the nineteenth century it extended to USA, where a powerful Innovation Movement was established which was active through the whole twentieth century. After the World War II, owing to the Innovation Movement, Japan developed so fast that it was justifiably called "the world economic wander". In Yugoslavia, organized Innovation Movement was active after 1975, upon decision taken on the highest level of authority in the country. In order to accelerate its economic development China also turned towards the Innovation Movement in the 1980s, and today it is the world economic power.

The innovation activity in USA deserves special attention. This activity was promoted by: Franklin, Washington, Hamilton, Adams, Jefferson, Madison, Lincoln and others. It was initiated in the eighteenth century and it intensively developed in the nineteenth century creating a country of powerful economy. It could be said that these leading figures, some of them the US presidents, initiated material progress not only of America, but of the contemporary civilization on the basis of the Newton learning. The genius of Washington reflects in the fact that, as the first elected US president and the creator of the Constitution of USA, he realized that he had to create additional centripetal force in order to preserve the Union, which was initiated with thirteen countries. This additional force was the strengthening of economical links between these thirteen countries after USA started to expand across the vast territory between the Atlantic and Pacific Oceans.

In the nineteenth century America experienced a powerful economic growth. In this period the inventors were much appreciated, some of them even became national heroes. They were the men of progress associated in the union of inventors – the famous Cooper Union. Some of these inventors from the very foundation of the Union were: Peter Cooper, Mc Cormick, Witney, Fulton, Westinghouse, Morris, Goodyear, Erickson, Gatling, Edison, Bell, Tesla, Pupin and many others. These names were very popular among American people and every man heard about them. America rejoiced at every new invention because it was well aware that it would speed up social and economic progress of the country.

It would be interesting at this point to give the example of "cotton gin" invented by Eli Whitney in 1793, and what it meant for the American people. This relatively simple machine very soon provided an enormous economic power to the Southern countries which produced cotton. Before this invention the cotton fibres had to be manually separated from the seedspods, so that only a half of kilo could be produced in one day. Now a slave could easily gin 25 kg of cotton, which quickly became a lucrative business of national interest for the American South.

Since the times of Washington the Presidents of USA, as a tradition, have been regularly receiving the most successful inventors once a year to present the awards. On the occasion of celebration of the fiftieth anniversary of the Edison's invention of bulb in 1929 the American President Herbert Hoover expressed his personal acknowledgment to the great inventor and the entire nation celebrated this as a national holiday. This fiftieth anniversary of the invention of bulb was celebrated worldwide and at that time Edison was 83 years of age. On that occasion on the very day when the bulb was invented, on 21st October, the lighting in the entire America was turned off for the duration of two minutes. At that moment Edison remembered the time of fifty years ago when his first bulb had been turned on – he had not left that bulb staying there for 45 hours until it had extinguished. He was young then, 33 years of age and full of faith that his bulb would conquer the whole world and that he made something big for the mankind. When Edison died in 1931, the US President gave the eulogy personally at the funeral.

That is the America in which worked one of the columns of the technological revolution – our Nikola Tesla. Tesla solved the technical problem of universal significance - electrical transmission of power along very long distances.

Thus, with his basic US patents 381968, 382280, 382279, 390413, 391414 he caused the Second Industrial Revolution.

Lead by Newton and Galileo the scientists discovered the laws of substance in motion, and lead by Faraday and Maxwell – the laws of electricity in motion. These are laws of nature, as eternal truths. The inventors James Watt and Nikola Tesla initiated the First and the Second Industrial Revolution with their inventions of steam engine and induction asynchronous motor.

Before the Watt's invention, the man had to perform all the heaviest work by applying the force of his muscles. Maximum use of electric energy and transmission of its power along very long distances started after Tesla's invention of polyphase system, contrary to steam engine. Until that time the engineers applied only direct current, convinced that it was impossible to make suitable motor for alternating current. Even after publishing Tesla's patents in USA and Europe, the experts retained such opinion until 1890. Alternating current has a number of advantages, it is easily generated, and its transformer enables transmission along very long distances in a very economy efficient manner. The first official success of the polyphase system was achieved during the Frankfurt Exposition in 1891. Electrical power was transmitted along distance of 100 miles whereas 30,000 V line generated the power to the three-phase motor designed by Dolivo Dobrowolsky. The entire project was managed by one of the most world famous engineers at that time, C.E.L. Brown, who admitted later: "It is Tesla we have to thank for the three-phase current applied near Frankfurt". Dobrowolsky claimed that he was the inventor of the key motor of polyphase system and that Tesla was an imitator, belittling Tesla's 20 H.P. motor with short circuit rotor, which Tesla sent to the Frankfurt Exposition. It took a while until Dobrowolsky realized that only Tesla's motor was the first practically usable induction motor, because its efficiency ratio was over 90% and its weight much lighter.

The great manufacturers lead a struggle against introduction of alternating current, although their system, in fact, slowed down industrial development due to numerous limitations. First, all mechanically generated currents are alternating currents; with one complicated device – commutator, which is the cause of many accidents, this current is translated into direct current through a motor making progressive shift of poles to achieve motor rotations. Both these actions are unnecessary in the new system (alternating current rectification in the generator and change the direction of current in the motor), because Tesla invented a motor in which alternating current directly shifts the poles, US patents no. 381968, 382280, and others.

The "War of Currents**"** began between the American companies owned by Thomas Edison, who developed his alternate current business also in Europe, and the Company founded in 1886 by George Westinghouse, who advocated alternate current and Tesla's patents. This war was fierce until 1893, and it was lead between two interest groups of big investors with growing needs for electrification of the American society. Tesla won the war in 1893, when the Westinghouse Company was awarded the contract for installing all lighting at the Chicago Worlds Fair held to celebrate the four-hundredth anniversary of discovery of America.

On that occasion a great power station was presented for the first time, and it was the biggest in the whole world. It included 12 Tesla's two-phase generators of 750 KW, which were driven by steam engines and produced two-phase current of 9000 KW in total. The frequency of these machines was 60 Hz, and the generators had 200 rotations per minute. In fact, they were generators made of two generators under Tesla's patent no. 487796 from 15th May 1888, as multi-polar generators with two armatures on the same axis with the windings shifted by 90°, so that the machines generated adequate two-phase current. Electromagnets consisted of 36 poles made of laminated mild iron which were attached to the joint casing. The armatures were constructed with grooves in which the windings were installed. Three dynamo machines, of 200 KW each, were planned for generation of direct current intended for excitation of poles.

These generators supplied dozens of thousands of bulbs and arc lamps, which provided electrical lighting, and also a large number of two-phase motors from 1 H.P. to 300 H.P., and commutators which generated direct current for special purposes. Several bigger two-phase motors activated three-phase generators which generated current for various three-phase motors which were exhibited in many electro technical exhibition departments.

On that occasion the Westinghouse Company exhibited various Tesla's motors and other devices which Tesla made in his workshops in 1887 and the devices which were made by Tesla at the railway workshop in Strasburg in 1883.

The International Commission chaired by the famous British scientists-physicist Lord Kelvin, who was against alternating current until the Frankfurt Exposition in 1891, after the success of Tesla's polyphase system in Chicago, departs from the Edison direct current system. The biggest investor of the Niagara Falls Power Company commenced construction of the powerful hydroelectric station with Tesla's patents. The contract with the Westinghouse Company was concluded in October 1893 after 7 years spent in worldwide search for the most appropriate solution.

The suffering of the winners Tesla and Westinghouse started only now since mass production commenced especially in America, Germany, Britain, France, according to Tesla's patents. It was disputed that Tesla was the author of the motor with rotating magnetic field, polyphase system of generation, transmission and use of alternating current. It was claimed, completely ungrounded, that the inventor of the rotating magnetic field was Prof. Galileo Ferraris, the Italian, and that the inventor of the induction motor and three-phase system was Dolivo Dobrowolsky, the German. Tesla was even named an imitator, that he took the Aragon's rotation from 1825, which was presented in Paris; the motor of Walter Baily announced in London in 1879; research of Marsel Depre in Paris in 1880; the US patent by Charles Bradley from 9th May 1887; and the Pottie theory from 1888.

Aware of the threats, Tesla protected his inventions of polyphase system also in Europe in due time. In Germany at the end of April 1888, he filed two applications for his patents with right of priority of the American application from 12th

October 1887**,** which included various combinations of induction motor, generator, polyphase system transformer with transmission lines. He was granted two German patents, no. 47012 and no. 47885, as early as 1st May 1888. All the US patents are described here (381968, 382280, 382279, 381969, 382281 – included in the German patents no. 47885 and 381970, 382282 – included in the patent no. 47012).

In the most significant German patent no. 47885, Tesla described the effect of the rotating magnetic field in the same manner as it was done in the US patent no. 381968; asynchronous motor from the US patent no. 382279 and the synchronous motor from the US patent no. 381969 were presented.

Although these patents describe the inventions identical to the discoveries described in the US basic patents, the patent claims are not identical, so that Tesla was not granted the same patent rights in Germany as in other countries. The main reason for this fact, in addition to the control of Tesla's patents, is found also in the German Patent Law applicable at that time, according to which the application filed in other countries did not grant the inventor the right of priority, because at that time Germany was not the signatory of Paris Convention. Germany protected the right of priority of the inventor in all countries which joined the Convention, subject to elapsing less than three months between the publications of the patent in one country and filing the application for the identical patent in another country.

Only in 1891, in its new patent law Germany recognized the right of priority to the inventors. Therefore, at filing applications for all patents, in Germany Tesla did not have right of priority as of date of filing the application for the US patents from 12th October 1887, but only from 1st May 1888, when the applications were officially received in the German Patent Bureau. On the other hand, in the meantime Professor Ferraris in Turin published his lectures held on 18th March 1888, in the form of a short article. The subject of these lectures was the production of rotating magnetic field with one-phase current and one artificially produced phase. The article about this lecture way published in April 1888, before Tesla had filed applications for his patents in Germany. But, despite all these facts, Germany did not opt to invalidate Tesla's patents on the ground of "new solution" principle, because "state of the art" in the world at the time when Ferraris held his lecture, included the solution of the rotating magnetic field from 12th October 1887 and the US patent no. 381968. Tesla's German patent no. 47885 relates to: the protection of induction multi-phase motor in which rotating magnetic field produces rotation of motor and the entire system of generation, transmission and use of polyphase currents.

The Court applies another principle of "abuse of patent monopoly", for the cases when patent has only market function, and supposedly protecting national interests, a principle intended to secure that the international patent system remains economical, development and human institute, is converted into its contradiction.

Despite this, the State Court in Berlin invalidated both above mentioned patents on 26th November 1898, based on the claim filed by German companies on the ground that Tesla did not apply his patents in Germany, and that these patents only served to obstruct development of German industry, what was completely untrue as we will see in the further text. The German State Court assumes an incomprehensible attitude that the German three-phase system, better known as "*Drehstrom",* did not fall under Tesla's patents. The Court claims that these are two different systems in spite of hundreds of expertises indicating that these two systems are the same thing.

This court judgement clearly indicates how the German industry used Tesla's inventions in the field of polyphase system; what various experts tried to prove that "*Drehstrom*" did not fall under Tesla's German patents and, moreover, how the invention of polyphase current and rotating magnetic field did not belong to Tesla, but to Ferraris and Dobrowolsky.

The proposal for forfeiture of Tesla's patents was filed by the well-known AEG Company, when the licence holder of these patents in Germany – HELIOS brought the action against companies AEG, SIEMENS and HALCKE on the ground of unauthorised use of patents. The expert of AEG Company – Dobrowolsky, a great German inventor, like many others, did everything to illustrate how Tesla had invented just an impractical two-phase motor. The basic discovery of polyphase current and rotary magnetic field, on the basis of which *"Drehstrom"* was developed, belonged to Ferraris. According to the opinions of the afore mentioned, the inventor of the three-phase system was not Tesla, but Gramme, Ferraris, Dobrowolsky, Bradley, Depre, Haselwander, Venstrem and others, who were the pioneers in the field of development of electrical engineering.

It is clear now why this was done. The German industry needed to be exempted from legal payment for the use of Tesla's patents. To this end, it was necessary to reduce Tesla's epochal achievements to certain impractical construction solutions and to point out that Tesla had reached such solutions on the basis of the great discoveries made by others.

Had the results of struggle against Tesla been limited only on the enormous material losses suffered by Tesla in Germany, we would not have dealt here in details with the wording of the decision of the German State Court. This has to be done because this decision contributed to the fact that the inventions of the three-phase system and the basic discoveries, such as polyphase current and the rotary magnetic field, are attributed to others in the professional literature, especially in many textbooks in different countries. At this point it should be emphasized that the legal assessor E. Arnold, whose worldwide known textbooks on electrical engineering speeded untruths about Tesla, participated in taking this decision of the German State Court.

In analyzing this court decision we come to many conclusions, the most significant of which will be stated here.

First of all, Tesla himself in his written statements to the court explicitly claimed that the contested German patents comprised his three-phase system, as it was the case with these US patents and the patents of other countries. This is clear from his sentence – "*when polyphase alternating current paved its way under the new mark "Drehstrom", this system was used by the German industry without*

authorization". Tesla submitted to the court various expertises by German and other experts, which claimed the same.

However, AEG Company and Dobrowolsky claimed that in the "world of experts" it was considered that the inventor of polyhase current was not Tesla, but Ferraris, and that the patent claim related to "Drehstrom" had been deleted from Haselwander's patent no. 55978 filed in June 1889 by the decision of the Patent Bureau issued on 13th November 1891, because this invention, allegedly, had been published earlier in the Bradley's US patent no. 390439, which, as the State Court states, had been granted to Bradley in October 1888.

The truth about Tesla's inventions, although much distorted by this decision, can not be denied any longer if we take into consideration the facts found not only in Tesla's US patents, but also in the German patents that had been forfeited from Tesla by court decision. On the basis of these facts Tesla first discovered not only polyphase currents and the rotating magnetic field, but also the basic inventions on the basis of which polyphase system had been created, and especially the three-phase system or "*Drehstrom*" system. The forfeiture of above mentioned patents illustrates only the extent of significance of Tesla's inventions for the development of industry in Germany and how the truth about the true values was in the service of profit.

This court decision included another significant conclusion related to the issue of dependence of the "*Drehstrom*" system on the wording of Tesla's patents. Even if Tesla's patent claims had been formulated in the way that envisages two conductors for each electric circuit, the "*Drehstrom*" system would have been dependent on these patents because it represents only one modification of the polyphase system comprised in these patents.

Reference to Haselwander's patent no. 55987 from June 1889 and to Bradley's patent no. 390439 is completely unfounded. First of all, not a single word in Bradley's patent relates to the three-phase system. It is neither clear how the AEG Company could have referred to that specific Bradley's patent, nor how the Patent Bureau could, by its decision dated 13th November 1891, partly invalidate Haselwander's patent on the basis of Bradley's patent. Bradley described a special application of the three-phase system in his patent no. 409450, filed on 20th October, 1888, and published on 20th August 1889. This patent relates to the three-phase generator with closed winding which is obtained when three-phase current is conducted from the direct current dynamo machine with three points, at 120 degrees distance between them, on the basis of the principle of delta connection. The identical invention represents also the basis for Haselwander's patent no. 55978 from June 1889. But, since this Bradley's patent was published on 20th August that same year, after filing the application of Haselwander's patent, within the meaning of the Patent Law effective in Germany at that time, it could not be used for partial invalidation. It is completely incomprehensible how the State Court could base its decision on such mistakes.

The fact that such invalidation still occurred could only be explained by taking into consideration Tesla's US patents 390413 and 390414, but not Bradley's patent, which were published on 2nd October 1888, and which comprise both star connection and delta connection with the three-phase system of 120 degree phase difference. The mistake made by the State Court in its decision is even more incomprehensible because these two Tesla's patents were explicitly stated in the decision itself in order to prove that Tesla would have protected the inventions comprised in these patents in Germany also if it only had crossed his mind to include the "*Drehstrom"* system into his German patents. This mistake becomes understandable only if one supposes that the intent was to avoid reference to these patents in connection with Haselwander's patents, due to absence of will to give credit to Tesla for inventing the "*Drehstrom"* system. Tesla did not file applications for these additional inventions in Germany because he considered that these additional inventions could not be used in Germany as separate inventions without the basic inventions which were described in the German patents and which included such special modifications. This particular fact is an evident argument against the decision itself, which is unreasonable and misleading in its statement that Tesla's German patents did not include the "*Drehstrom"* system.

Not only the patent claims, but the entire wording of the patent application should be taken into consideration in the interpretation of the far-reaching effects of the inventions since Tesla's patents in Germany dated from 1st May 1888. In order to understand the decision of the State Court in Germany and the unusual procedure behind it, it is necessary to take into consideration the entire patent application of Tesla's German patents, although the extracts stated here and other explanations will be sufficient to illustrate the lack of grounds found in the wording of the German court decision published in the court announcements in the beginning of 1899. This text in its entirety reads as follows:

V. COURT DECISION OF THE STATE COURT AND CIVIL SENATE FROM 26TH NOVEMBER 1898

Revocation of the patents No. 47012 and 47885, the property of Nikola Tesla, the electrician, due to their failure to work in the territory of the German Reich. – The patentee should be recognized for the carrying out not by him or the holder of his licences, but by the others against his will and with infringement of his patent rights. – Three-phase system (Drehstrom) is not covered by the disputed patents. – Granting the licence to a community capable of conforming to the obligations from the patent does not relieve the owner from his duty to carry out which is compulsory for him. – Under some circumstance, the carrying out realized after submission of claim for forfeiture of the patent may be considered in favour of the patentee. – Mistakes of the patentee regarding far-reaching effects of his patent shall not make his excuse for failure to carry out.

In the patent dispute of Nikola Tesla, an electrician from New York, represented as the defendant and claimant by the Helios Electrical Joint Stock Company in Cologne, – Erenfeld, against AEG Company (General electric company) in Berlin, as the claimant and defendant regarding the forfeiture of the patents 47012 and 47885, the State Court, the first civil senate at its session of 26th November 1898, made the following Decision:

The Decision of the King's Patent Bureau of 10th December 1896 is hereby confirmed. The claimant is obliged to pay the costs of the appeal procedure.

VI. REASONES

The claimant demands in his action of May, 1895 that the defendant be forfeited of his patents nos. 47012 and 47885 granted to him on 1st May 1888, because the patented inventions have neither yet been carried out in the country nor any action has been taken to insure such carrying out.

* * *

This statement of the claimant was not correct, because it was Tesla who had the greatest interest to have his inventions applied, and such Decision of the Court is not understandable. Tesla did everything to have his patents applied, not only in USA, but also in Europe, especially in Germany by granting his licence to Helios.

Tesla, being an alien in Germany, appointed his agent – The Joint stock company Helios from Cologne. He granted an exclusive licence to this Company in 1892 for use of two patents. He made a licence agreement with this well-known and reputable company to insure application of the patent in Germany. Helios was not in position to build big electric plants in accordance with the Tesla's patents because the other companies, including AEG, had huge privileges. Namely, they used the patents of the defendant without paying any fee, when the multi-phase alternating current cleared the road under the name *"Drehstrom"*. Helios had to initiate a whole series of patent infringement claims against Siemens and Halske in Berlin and Kemnic, Oscar von Miler in Munich, Virtenberg Cement factory in Laufen and Vilhelm Raizer Company in Stuttgart. On the other hand, F. Lachmayer & Co. initiated the action against Helios with a motion to determine absence of patent infringement in application of *"Drehstrom"*. Helios also took all possible actions to use the patents in practice. On many occasions an engineer was sent to the States to obtain instructions for practical execution of the patent; then, transformers and engines were built for the purpose of the patent, that were stored at Helios ready for sale. The Company offered the licence to some other counterparts. Helios made further efforts in that regard, and after initiated claim the Company concluded a Licence Agreement with Union Company in December, 1895. It started construction of the electric power station in Cel, and its own factories for manufacture of the electric plants, in accordance with the Tesla's German patents, without any modifications. Helios had negotiations with the city of Dortmund and Count Henkel – Donersmark about construction of an electrical power plant.

In the end, regarding the shameful court decision, we can just note that in his German patent No. 47885 Tesla was not only the inventor of the multi-phase current and rotating magnetic field, but also the patentee of the asynchronous and synchronous motors which are the precondition for application of both the general polyphase system and *"Drehstrom"*. Failure to mention these grand inventions in the Decision of the State Court, despite their explicit protected status through the patent no. 47885, pursuant to German law of that time, is an unrecorded precedent in the international patent law.

* * *

The situation in USA was not much better, because Tesla's patents were also used without authorisation by many companies during the fast US electrification.

Tesla's patents in polyphase systems were the cause of many judicial proceedings, due to a large number of their unauthorised use in US, Germany, France and even England. It is understandable, because for many years these patents covered a wide range of generation, transmission, distribution and use of the electrical power by means of the polyphase system. Many companies and individuals tried to use the main Tesla's ideas to create their own systems, which they, which according to them did not fall under Tesla's patents.

The Decision of the Connecticut Circuit Court, USA, is of special importance for the truth, because it states that Tesla's basic patents 381968, 382280 and 382279 from 1887 comprise all systems used by different inventors, a three-phase system in particular, that has been applied in a number of modified alternatives. That Decision was elaborated in details by the patent judge TOWNSEND, who took into consideration all pleas related to Tesla's patents.

The lawsuit was initiated by *Westinghouse*, the owner of Tesla's patents, against *New England Granite Company*, which was producing multi-phase generators and engines without authorisation. This Decision of the Circuit Court in Connecticut, is a judicial acknowledgement that the whole polyphase system in terms of its basic principles, inventions and discoveries is Tesla's work and that the entire development of electro-techniques, based on the main Tesla's patents, resulted from the simple implementation of the epochal Tesla's ideas, and Judge Townsend says: *"It remained to the genius of Tesla to capture the unruly, unrestrained and hitherto opposing elements in the field of nature and art and to harness them to draw the machines of man..... What others looked upon as only invincible barriers, impassable currents and contradictory forces he seized, and by harmonizing their directions utilized in practical motors in distant cities the power of Niagara."*

Townsend's judgement was made public on September 19, 1900. We will quote only some of the parts from the judgement, to illustrate how thorough and professional it is:

"The patents being the subject of the case relate to the process of electric transmission of the power by use of the mechanically generated alternating electrical currents.

. . . . . .

Every mechanically generated current is alternating current in its nature. It was thought earlier that it was impractical to use mechanically generated currents before their alternations were rectified by means of commutators that changed the current direction so that the current flows through conductors continuously in one direction. The currents periodically rectified by means of the commutator, which breaks current between two direction changes and conducts it in sections are known as rectified or changed current. We should be more careful about this difference between the alternating and changed current. The alternating current keeps flowing in the opposite directions, in the same

way as originally generated. Changed current is rectified to flow in one direction and as such it is known as direct current. When rectified by the commutator to become direct current, it loses some characteristics essential for its greatest effects.

Before Tesla's inventions, power was transmitted only by direct electric current. Application of that power transmission system was restricted for many reasons, one of which is unsafe use of strong currents for long distance supply of high voltages. On the other hand, the real alternating current had practically immense potentials in strength and voltage, and the voltage could be changed economically by a transformer. However, in spite of all this, such fast change of direction of the alternating current before Tesla's inventions, disturbed motor operation from its start and during its rotation, except when synchronisation with the generator was achieved. For this reason, alternating current was not applicable in situation of load change.

The problem faced and successfully solved by Nikola Tesla was: How to overcome the difficulties occurring in use of the alternating currents and use their energy for unlimited transmission of power.

. . . . . .

"His large-scope invention, briefly explained, eliminates the problem with motors, and consists of production of progressive movement of the magnetic field (or motor poles) by means of two or more independent alternating currents in different phases, and electric circuits that provide independent character and phase relation of such currents"

.. . .

The lawyer of the defendant says: "For this reason, it comes out that the claimants request a wide-scope patent protection. On the other hand, the Defence thinks that this invention had been known long time ago, that its application has been in use for years, and that since the time of Arago there has never been room for such invention, and that the state of the art is the result of past developments, including Arago's rotation, achieved by simple implementation of the engineering skills of the capable electricians who implemented their knowledge in accordance with the progressive needs of the day, plus special inventions related to the motors or generators or different connecting current circuits. It does not give any right to Tesla or any other patent owner to prevent sale of generators and motors by possessing the patented system which includes everything."

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In support of their evidence, the defence refer to four published documents: Baily's article from 1879, Siemens patents from 1878, Depre's article from 1880-1884 and Bradley's application of May 9, 1887 and his patents."

Townsend mentions the German judgment and quotes, lengthily in parts, Argon's rotation and Siemens English patent from 1878, which relates to the advancement of the device for electricity generation in a dynamo machine and regulation of the electrical power for lighting purposes. The judgement states that on May 9, 1887, about 6 months before Tesla's patent applications were filed, Charles S. Bradley filed his application for a dynamo-electric machine (one generator for conversion of the mechanical energy into electric energy). Judge Townsend continues:

"Comparison of Bradley's application, which has been filed before Tesla's patents application, with Bradley's patent No. 409450, which was published on August 20, 1889 after Tesla's patents, reveals that the application describes the method and explains the apparatus specified to avoid accidents with two-phase alternating currents by combining both currents in one by use of one transformer. In the patent, Bradley omitted the description and method, and introduced the pictures, which despite their striking resemblance to the apparatuses demonstrated by Tesla, cannot prove that Bradley made the Concept of the Tesla's idea, or that he thought to protect the subject of the Tesla's invention. Because Bradley's application is indefinite and of limited objective, and because it does not show that Bradley had any concept of the Tesla's idea of "utilisation of motor on the basis of progressive movement of the magnetic poles of the alternating currents by use of electric circuits, which provide independence and different time relation of their phases", and because, even if Bradley was the first creator of that concept, the concept was insufficiently described to explain the principle or method of work, and finally, because Tesla was the first to practically implement such principle, Bradley has neither anticipated nor limited it.

The Defence placed main hopes on the article of Mersel Depre from 1880-1884, and they were right, because Depre not only presented the principle used by Tesla, but also gave a mathematical explanation of the rotating magnetic field. The claimant's experts also say:

"The article explains a mathematical fact, which has also been determined in the Tesla's patents, that the polar line in a circular magnet can move along its full perimeter under the action of the two magnetization forces in adequate relation."

Judge Townsend quotes Depre's article and says:

"All that Depre said was, that when a field is created where an electromagnet changes its position in relation to the brushes, or vice versa, the angle of such change can be reflected in another machine by means of a compass needle, which will rotate faster or slower depending on how the magnet and brushes move towards each other, and will indicate a new angle between the brushes and the magnet. One useful and practical application of that device was to connect it to the power generators and use land or vessel to demonstrate change of position by means of the compass needle on the top of the mast. These devices could not induce anybody to think that the alternating currents can be used as the engine power source. It was an indicator only. It did not include utilization of two different phases as a power source in generation of the permanent magnetic field. It did not rely on any permanent, regular, progressive currents, and as demonstrated by evidence, it was, according to recognition, only a laboratory experiment, like the Baily's device. That Depre did not know about the concept of the Tesla's idea to use regular, progressive, permanent alternations of the current, was proved by Depre himself in his statement from 1889, after publication of his lecture and after Golla and Gisp's invention of the system of the alternating current for lighting purposes, when he published his second lecture where he criticized that system and stated that one of the biggest obstacles for the system is its impossible application on power

transmission, and added: "Further, I must note that the alternating currents are not usable for power transmission; they are only suitable for lighting."

Finally, the proofs show, as Professor Sylvanus Thompson says in his work on that general subject: "Depre's theorem was not fertile; it remained just a geometrical abstraction."

The main idea expressed and applied in Tesla's patents was that fast successively opposite alterations of the alternating current, that are regular and constant in such different phases, be used not only to prevent them halt the armature, but also to become a source of power. To carry out that idea in practice, alternations had to raise and fall and follow in sequence progressively and continually, as the Claimant's expert says: "like locomotion lever, which has no dead point, but pushes only forward". Tesla's invention, in its essence, consists of permanent rotation or whirling of magnetic forces for generation of power, where two or more shifted or different phases of the alternating current are developed, and transmitted into the motor where they remain separate, and where such shifted phases are used in the motor.

Baily does not describe use of the alternating currents of the shifted phases. He just describes intermittent movement of poles by means of the commutator or switch, and that is what Tesla denies. Neither Siemens nor Bradley describes use of such shifted phases of the alternating currents with their independence maintained in the motor.

What was the state of the art in 1887, when Tesla filed his patent applications?

Nine years passed since the patent was granted to Siemens, which, according to the defendants is "complete disposition of the main contents of the published patents 381968 and 382280" and "reference to them ... in the hands of skilful electricians ... would naturally lead, as can be understand by itself, to the organization of elements that contain the system of electrical power transmission and substantially include the system of the earlier mentioned patents. Eight years passed since Baily's lecture. Four years passed since Marsel Depre's article, who, as the defendants state, "described the same thing that is claimed by the claimant to be Tesla's discovery, and explained the theory of operation", of a device which is "a generator of two-phase alternating current according to its way of function and generates two-phase alternating currents to generate rotating field inside the motor", similar to Tesla's motor.

Before Tesla's invention, alternating current motors were not in use, despite great needs.

. . . . . .

Siemens, who was mainly quoted to support the evidence, does not describe any use of the alternating currents nor reports on use of commutators, but only mentions use of these devices in the function of an electric machine "with suitable modifications" that have never been described in the literature.

Impracticality of the motor with changed current direction, generated by the commutator, shows that Siemens, Baily and others did not have any knowledge about the discovery of the Tesla's invention; they took into consideration the lighting electrical machines with commutators.

Tesla was the first who discovered the way how to use these alterations for such purposes and demonstrated both the machine and method adapted for such use.

. . . . . .

However, if the evidence presented up to now are not taken into account, and if we consider the alternating currents and the currents of changed direction to be theoretically known equivalents, even then this is not favorable for the Defense. They believe that the great results obtained by replacement of one known equivalent with the other does not make an invention. But, the first substitution or application of such theoretical equivalent for creation of a new or non-equivalent or unexpected result may contain an invention. Tesla applied alternating current to achieve what the current of changed direction could have never given: namely, to produce a new, unpredictable and practical power transmission system."

Careful examination of evidence lead Judge Townsend to a conclusion that Tesla made a new extraordinary discovery, without diminishing the level of Tesla's invention. It was proved that by a new combination and arrangement of the known elements, he obtained a new and useful result that has never been achieved before, thus leading to a new industrial revolution.

* * *

Judge Townsend made his Decision only after long oral judicial proceedings, where the main person of the accused company *"New England Granite Co."* was B.A. Berend, an expert well-known in practice. We are giving here his statement, that was printed in the second edition of his book *"The Induction Motor"*, published in 1921 in New York, pages 261 and 262 and reads:

"Twenty years ago it seemed that the author of this book supported infringement of the Tesla's patents, in connection with his employment. A large number of the induction motors designed by him during the term of these patents, which was full infringement of the Tesla's inventions, was an undisputable reason to believe that he either did not have trust in the validity of these patents or was deliberately involved in patent right violation.

The company where the author was the chief engineer at that time, had to be highly grateful for its development and growth to his personal endeavors in designing and developing the electric machines, and to his successful organization of the engineering staff comprising a whole range of excellent experts including David Hall, A. B. Feld, W. L. Waters, Bradley T. Mc Cormick, H. A. Bourzon, Alexander Miller Gray, R. B. Williamson, Carl Fecheimer, and others. At that time, the owners of Tesla's patents initiated the proceedings against our company, and the position of the author during these long proceedings was occasionally very unpleasant and brought him into two minds. That is why he, feeling still bitter because of these past proceedings, now asks for permission to publish a letter addressed to the patent lawyer of his company in the epilogue of the:

Cincinnati, Ohio, 23rd May 1901. Mr. Arthur Stam Patent Lawyer In the city.

Dear Sir, herewith enclosed you will find my comments on the report of Feinal Hiring in the case "Westinghouse Electric and Mfg. Co." versus "New England Granite Co."

You will see that I am now convinced more than I was earlier that it is not possible for us to submit further evidence which could prove invalidity of the Tesla's patents that are the subject of the judicial lawsuit. Although I am an employed engineer very willing to give you every technical support I can, according to my official duty, on your request and for your requirements, I cannot oblige myself to speak in favor of my employer in this case, because such action would be against my higher believes in this matter. Since you informed me during my last visit to your office that I should be one of the experts, I think it is the best to inform you at the earliest convenience that I am not in position to assume this task.

Model maker Mr. V. J. Sultz paid a visit to our office yesterday and I gave him all necessary instructions to make the device that we think should be made for this proceeding. In this way, Mr. Sultz is prepared so that we can have trust in him that this will be made and presented to our headquarters. I remain, Sincerely yours, B. A. Berend, Chief-Engineer, etc.."[*] 1

This recognition of B. A. Berend is of great importance for the truth for two reasons.

First of all, it proves that publication of Tesla's patent in USA was immediately followed by building the large number of induction motors, and that their producers did not pay attention to what extent they were in conflict with Tesla's patents. Patented inventions had such effects on further development of the electronic engineering so that some companies did not hesitate to be involved in the judicial proceedings believing the benefits of the unauthorized use of Tesla's patents would far outweigh the losses in connection with the charges they pay for lost lawsuits. They did not shrink from any means to contest patent rights and prove existence of the polyphase systems not covered by them.

The leading experts of that time, the most prominent of whom were Brown, Berend and others, were aware that they built multi-phase motors and generators fully infringing Tesla's patents. Berend was not only a famous designer, but also a theoretician in the field of polyphase system and he published a whole range of scientific papers, which resulted in, so called, pie-diagram, which is partly known in literature as Highland's diagram. That diagram is theoretical explanation of relations in an induction motor operating under different loads, and gave great results in calculation of motors of various sizes for different kinds of drive. Recognition from such expert is undoubtful evidence that in the history of the polyhase system many efforts were made to diminish Tesla's credits and to link Tesla's inventions to other names. Ferraris, Dolivo Dobrowolsky and many other inventors are among those who are in literature credited for discoveries and inventions, clearly explained in Tesla's patents.

Townsend's decision is important from the professional aspect and illustrates that he is top patent expert.

The most important is his explanation of the term "independent" that relates to the multi-phase electrical circuits. Townsend had quite correct view that the application of multi-phase currents for generation of the rotating magnetic field in the motor essentially requires electrical circuits to provide necessary "independence" of each phase in its action and that the current generated in a generator in one phase acts as such in the motor.

The second important statement is that there is significant difference between the alternating and direct current. According to Townsend, this significant difference between these two ways of generation of the rotating magnetic field consists of inability to use high voltages in case of direct current, while the alternating current can be successfully used for this purpose along very long distances. Direct current is requires a commutator, for generation and change of direction. In addition to it, a commutator which rotates by means of a special mechanical device must be used for change of direction. Alternating currents do not need commutators and the voltage can be changed by transformers when necessary, while always maintaining the alternating character of the current.

The third statement is that Tesla's basic patents include multi-phase generators and multi-phase motors. It is clear from the patent claims that were denied, because they refer to the combination of multi-phase generators and motors. The discovery of multi-phase currents is related to multi-phase generators, which do not include the generators with separate groups of windings as were earlier used for supplying different electrical circuits in the arc lamps. Townsend's decision says that Tesla is the inventor of multi-phase generators and motors, no matter they are two-phase or three-phase currents, or three, four or more conductors are used for transmission of these currents.

The fourth statement is of principal significance, that neither Tesla nor other owners of his patents can have the right to preclude sales of the generators and motors, but only their production. At this point, the Judge demonstrates his knowledge of the patent system, because he does not approve so called "market function of the patent" that hinders every development.

VII. Conclusion

It is difficult for the small nations to have great people because a genius needs great environment to develop his ideas. The best example is Tesla. Large country facilitated creation of his patents which were the driving force for the Second Industrial Revolution and the inclusion of his name among the builders of the world civilization. He is a winner not only because of the Townsend's decision, but because the world generally recognizes that Tesla invented the system for the long distance transmission of electrical power.

However, it was not easy. Human malice and greed for money destroyed Tesla materially, but his spiritual values

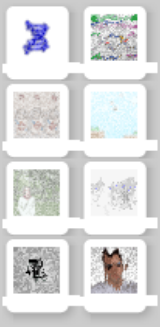
[*] 1 The Induction motor and other Alternating Current Motors, by B. A. Behrend, fellow, and past senior vice president, American Institute of electrical engineers fellow, American academy of arts and sciences, etc.

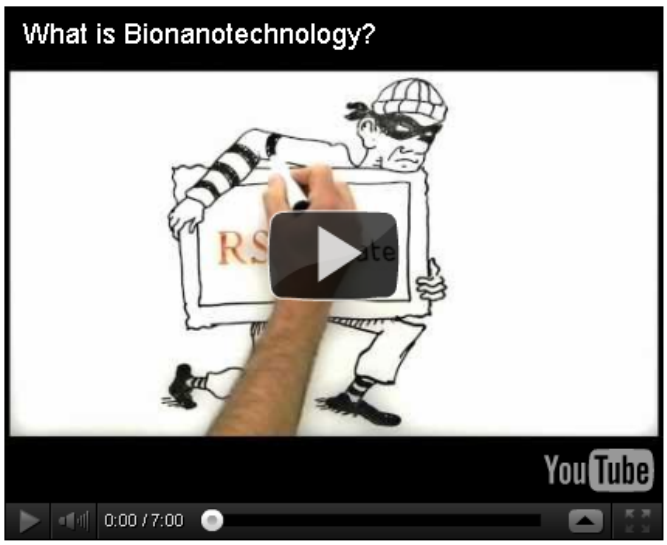
Mc Gvaw – Hill Book Company, New York: 370 senect avenue, 1921, p. p. 261 – 262.

were still shining with full radiance to the welfare of the human kind. These values could not be diminished by the astronomer Arago from Paris, or Ferraris – professor from Turin, who were attributed the invention of the rotating magnetic field. Siemens' patents from 1878, Baily's experiment from 1879 in London, "one way to generate Arago's rotation", and the research work of the great French scientist Depre from 1880, who used higher voltages for transmission of electrical power, are insignificant because they all fail to describe the use of the alternating current. The patents of Bradley, a great American inventor, from 1889, did not have anything to do with the ingenious Tesla's work. Although Dolivo Dobrowolsky together with the German inventors Schuckert and Haselwander and the Swiss Brown, made "the first polyphase system" near Frankfurt in 1891, the credit was on Tesla because later they themselves admitted that all technical innovations belonged to Nikola Tesla.

There remains the shameful decision of the State Court of the German Reich from 1898, which made a lot of problems for Tesla and almost ruined him financially. Invalidation of Tesla's patents excused by their "failure to work" means certain kind of compulsory license is introduced. The Court probably assessed that this was the best way to help German companies AEG, SIEMENS and HALCKE that stole Tesla's patents and close HELIOS and other German companies which had legal production in accordance with Tesla's patents. The forces of greed destroyed only Tesla's material values and all lawbreakers with their confessions and remorse only made his spiritual values greater.

Available time prevented us to address the fraud by Edison and Marconi, a judicial proceeding in connection with Tesla's radio patents, and the roles of the courts in USA and Great Britain that consumed many decades. In his book to be published soon, the author explains in details the German, American, French and British judgments.





I am interested in inventing new methods to construct and manipulate biological molecules at the nanometer scale. I'm currently a fellow at the Wyss Institute for Biologically Inspired Engineering.

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Described herein are embodiments of a portable wireless power charger that includes a charging region including a high-Q source magnetic resonator configured to generate a magnetic near-field for coupling of wireless power to a wireless powered device including a high-Q receiver magnetic resonator,...

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Described herein are embodiments of a power supply system that includes a power supply coil and a power supply-side resonance coil that are provided at a facility, a power receiving coil and a power receiving-side resonance coil that are provided for a mobile unit, a power supply-side information...

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Described herein are embodiments of a transmitter that includes a substantially two-dimensional high-Q resonator structure including a flat coil; and an impedance-matching structure operably connected to the resonator structure, the transmitter configured to transmit power wirelessly to another...

29. Aristeidis Karalis, Andre B Kurs, Robert Moffatt, John D Joannopoulos, Peter H Fisher, Marin Soljacic: Wireless energy transfer. Aug, 11 2011: US 20110193419 (1 citation)

Disclosed is an apparatus for use in wireless energy transfer, which includes a first resonator structure configured to transfer energy non-radiatively with a second resonator structure over a distance greater than a characteristic size of the second resonator structure. The non-radiative energy...

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Described herein are embodiments of a transmitter that includes a modulation circuit configured to modulate a power carrier signal with an information signal to form a modulated signal; and a high-Q resonator configured to couple with a high-Q resonator of a receiver, wherein the resonator is...

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(12) **Patent Application Publication**

Karalis et al.

(10) **Pub. No.: US 2011/0089895 A1**

(43) **Pub. Date: Apr. 21, 2011**

(54) **WIRELESS ENERGY TRANSFER**

(76) Inventors: **Aristeidis Karalis**, Cambridge, MA (US); **Andre B. Kurs**, Cambridge, MA (US); **Robert Moffatt**, Reston, VA (US); **John D. Joannopoulos**, Belmont, MA (US); **Peter H. Fisher**, Cambridge, MA (US); **Marin Soliacic**, Belmont, MA (US)

(21) Appl. No.: **12/949,580**

(22) Filed: **Nov. 18, 2010**

Related U.S. Application Data

(63) Continuation of application No. 12/437,641, filed on May 8, 2009, which is a continuation of application No. 12/055,963, filed on Mar. 26, 2008, now Pat. No. 7,825,543, which is a continuation-in-part of application No. 11/481,077, filed on Jul. 5, 2006, now Pat. No. 7,741,734, which is a continuation-in-part of application No. PCT/US2007/070892, filed on Jun. 11, 2007.

(60) Provisional application No. 60/698,442, filed on Jul. 12, 2005, provisional application No. 60/908,383, filed on Mar. 27, 2007, provisional application No. 60/908,666, filed on Mar. 28, 2007.

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(51) **Int. Cl.**

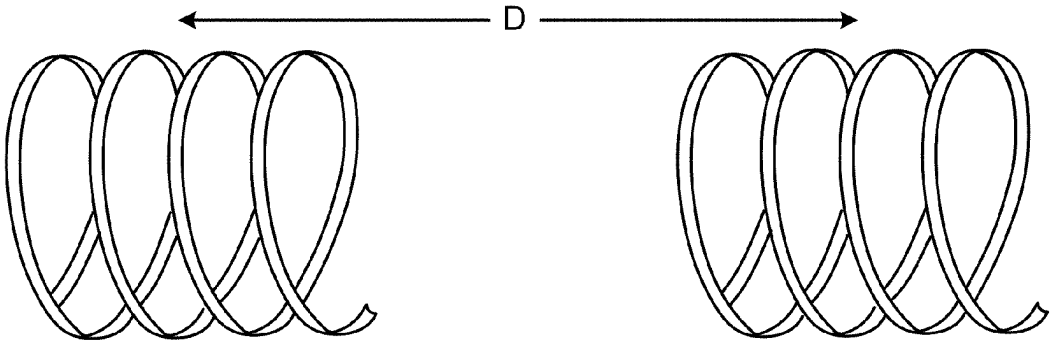
H02J 7/00 (2006.01)

H02J 17/00 (2006.01)

(52) **U.S. Cl.** **320/108**; 307/104

(57) **ABSTRACT**

Disclosed is an apparatus for use in wireless energy transfer, which includes a first resonator structure configured to transfer energy non-radiatively with a second resonator structure over a distance greater than a characteristic size of the second resonator structure. The non-radiative energy transfer is mediated by a coupling of a resonant field evanescent tail of the first resonator structure and a resonant field evanescent tail of the second resonator structure.



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US Pat. 12896400 - Filed Oct 1, 2010
... one could use it to implement optical inter-connects for **CMOS** electronics, or to transfer energy to autonomous nano- objects (eg MEMS or **nano-robots**) **...**

[APPLICATION] WIRELESS ENERGY TRANSFER
US Pat. 12949580 - Filed Nov 18, 2010
... one could use it to implement optical inter-connects for **CMOS** electronics, or to transfer energy to autonomous nano- objects (eg MEMS or **nano-robots**) **...**

[APPLICATION] WIRELESS POWER BRIDGE
US Pat. 12784615 - Filed May 21, 2010
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[APPLICATION] WIRELESS POWER SYSTEM AND PROXIMITY EFFECTS
US Pat. 12708850 - Filed Feb 19, 2010
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[APPLICATION] TRANSMITTERS AND RECEIVERS FOR WIRELESS ENERGY TRANSFER
US Pat. 12732399 - Filed Mar 26, 2010
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[APPLICATION] MAXIMIZING POWER YIELD FROM WIRELESS POWER MAGNETIC RESONATORS
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US Pat. 12717559 - Filed Mar 4, 2010
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[APPLICATION] HIGH EFFICIENCY AND POWER TRANSFER IN WIRELESS POWER MAGNETIC RESONATORS
US Pat. 12726953 - Filed Mar 18, 2010
... one could use it to implement optical inter-connects for **CMOS** electronics, or to transfer energy to autonomous nano- objects (eg MEMS or **nano-robots**) **...**

[APPLICATION] WIRELESS ENERGY TRANSFER
US Pat. 12949504 - Filed Nov 18, 2010
... devices (eg artificial hearts, pacemakers, **medicine** delivery pumps, etc. **...** one could use it to implement optical inter-connects for **CMOS** electronics, **...**

[APPLICATION] RESONATORS FOR WIRELESS POWER APPLICATIONS
US Pat. 12726913 - Filed Mar 18, 2010
... devices (eg artificial hearts, pacemakers, **medicine** delivery pumps, etc. **...** one could use it to implement optical inter-connects for **CMOS** electronics, **...**

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NO i doubt it. Tucker was about innovation and moving forward. The big 3 didnt like all that because it cost them money. Tucker was trying to be innovative and create cars that were ahead of there time. Its funny how in his speech in the court he talks about how if they dont move forward the competition will beat them and the big 3 will wonder why. Funny how that actually happend in real life and now the big 3 are trying to stay alive.

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I watched this in Business class

MrCubehead58 2 months ago

It's too bad Tucker never succeeded. Who the hell knows what the car could've become had it been allowed to be produced. Whether he would've taken over the automotive industry or not, remains to be seen, but he had some awesome ideas that I believe should've been allowed to be built.


0:35

Just dance 4
by justdancegame
41,711 views
Ad

3:47 Featuring a Tucker Prototype II - one off
by zillis
52,258 views FEATURED

8:53 TUCKER "The Man and the Car" 1948 (part 1)
by TheLaughingBandit
55,670 views

8:10 Tucker Convertible 57 We take a short ride in
by RideswithChuck
39,058 views

4:00 Garage Find: Tucker Automobile Company
by 4spdBernie
61,932 views

6:01 TUCKER "The Man and the Car" 1948 (part 2)
by TheLaughingBandit
50,695 views

4:05 1948 Tucker
by vintagevehicleshow
21,263 views

0:31 1948 Tucker Sedan Starting and Idling
by TuckerClubofAmerica
79,776 views

10:04 1948 TUCKER # 10 Drager's International
by dragersclassics
27,304 views

10:55 Tucker Convertible @ Keels & Wheels May
by gsriley1
11,244 views

2:15 Tucker #1038 at the 2008 TACA Convention
by TuckerClubofAmerica
85,375 views

1:54 The Tucker Car Show
by CarShow
53,551 views

1:39 Preston Tucker Speaks My Mind.mp4
by tonyin954
8,268 views

1:25 Barbarians at the Gate trailer
by Faluvégi Balázs
25,337 views

1:24 Tucker '48 Sedan
by ExoticAffinity
14,815 views

2:09 1948 Tucker Classic Car
by citizengar
6,348 views

Seattlecarnut 6 months ago

How about a 5.5 liter, 6 cylinder, rear engined, 25 mpg, 125 mph in 1947, 6-seating, record braking, family sedan that has a helicopter engine, and an "electronic" manual transmition in witch you could survive a head on colision at 55 mph with a truck and that only 51 of witch have been built ever and also that is still much more revolutionary then any thing dodge came up with. TUCKER

PetarVN in reply to williamg2552 (Show the comment) 8 months ago

What about a Dodge Challenger Hemi Convertible ?

williamg2552 in reply to the14u36 (Show the comment) 9 months ago

Thumbs up if u watched this for a class assigment

iloverobinH 9 months ago

one of these just sold for 2.6 million on barret jackson. nothing ford or dodge together ever build sold for that much.

the14u36 9 months ago

im the 60,000 th on this site.

i was in the movie it was a great movie , well made contraption.

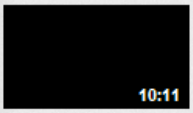
hold that tiger.

pl

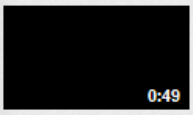
ps named my #2 son TUCKER

sapiscnn 10 months ago

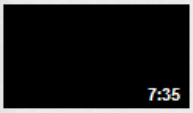
1 2 3 4 5 6 7 Next »



Land of Chocolate for 10 Min!
by ManuelMendozaTV
60,724 views

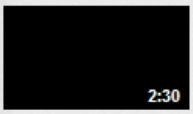


The Tucker Convertible's Engine is
by 1badbadger
13,292 views



Benchmark Classics & Previous Owner of
by 1badbadger
2,212 views

Trailer Thirteen-Days
by VoRnAmE12
316,506 views



Tucker OST - Captain of Industry (Overture)
by rohstoffTM
15,498 views

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