The Implications of Interfacing In-The Body Technologies to the Outer World- The Impending Era of Human-cyborgs

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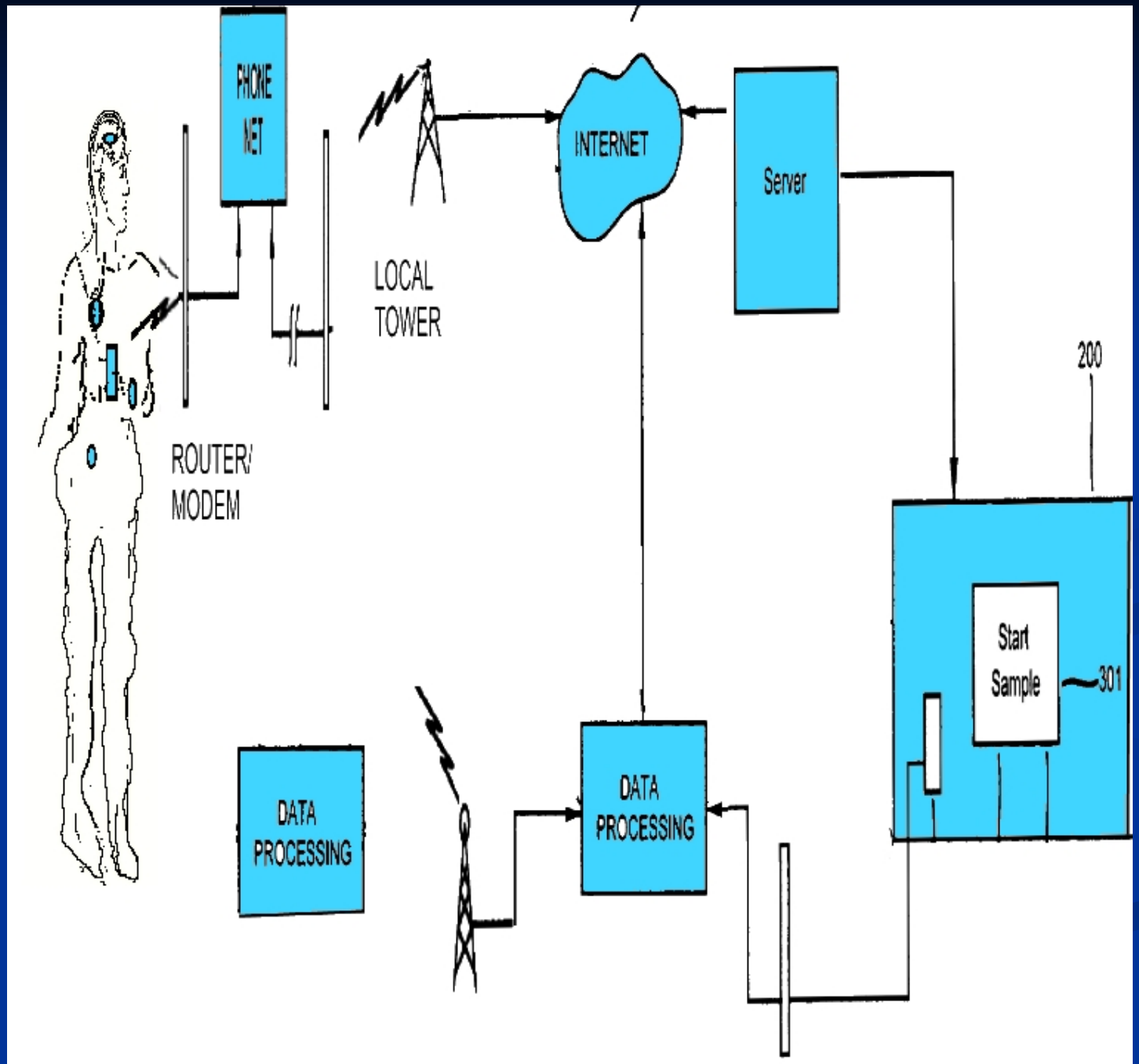
This paper discusses aspects of the technical and consequential legal implications of the proliferation of implantable in-the-body technologies and their telemetric connection to commercial, medical and governmental networks.

Keywords: cyborg-assisted life, implantable technology; in-the-body technology; cyborgization law

Today's Presentation will address:

- The idea that we are headed for a society whose dependence on in-the-body technology will create virtual human-cyborgs.
- An overview of technology that will have a major impact on health and non-health related apps to enhance lives and augment connectivity.
- A legal perspective about the consequences of connecting in-the-body technology to telemetry.


PHONE NET
INTERNET
Server
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200
ROUTER/ MODEM
Start Sample
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DATA PROCESSING
DATA PROCESSING

A Boundary Not Too Far

- Presently in-the-body medical devices bi-directionally radio communicate with remote computers utilizing the Medical Implant Communication Service frequency band between 401 MHz and 406 MHz.
- The maximum power transmission is 25 microwatts, a range of a couple of meters.
- The maximum bandwidth is 300 kHz, (low bit-rate systems), compared with WiFi or Bluetooth.
- Nonetheless these devices can transmit to a receiver connected via USB to any computer ready device through local area networks (LAN), wide area networks (WAN), and access the Internet.

Technology Applications

- Computer stimulators and suppressors for alleviating e.g., pain, depression, neurological diseases, such as Parkinson's, heart, diabetes, incontinence;
- Artificial organ processors to replace any one of nearly two dozen major body organs;
- Internal computer processors will enhance knowledge, skills, countervail against environmental challenges (e.g., climate);
- Prosthetics to replace malfunctioning, missing, or damaged body parts;
- Implanted analytical and diagnostic tools drawn from an array of bioinformatics technologies;
- RFID chips to be embedded beneath the skin for personal identification and for integrating humans into the supply/demand chain.

The Computerized Anatomy Is A Matter Of When, Not If

- The 2010 global market for microelectronic medical implants, accessories and supplies has been estimated at US$15.4 billion and by 2016 forecasted at US$24.8 billion.
- Ray Kurzweil, a leading futurist, recently opined that implantable health related devices would be seen by 2020 and a decade or two later will go beyond medical appliances.

Major Milestones

- The three drivers behind increasing computer implantation are bioengineers have reached a critical mass in converting computer technology into lifesaving and life enhancing products;

- Computers and their software, the backbone for these products are becoming ever more computationally sophisticated based on the accumulation of scientific knowledge;

- Between 2012 and 2020 processor speeds will increase from an already astounding 40 billion operations per second to 330 billion operations per second;

- Substrates, that is the material part of the computer, now measured in micrometers or the size of blood cells, will dive deeply into the realm of wafer-thin graphene (carbon) and MoS2 (molybdenum disulfide) measured in nanometers, just a few atoms thick.

It's a Small, Small World

- Nano-stimulators/suppressors, artificial organ processors, metabolic and cognitive enhancers, and permanent diagnostic tools to ensure our physical and psychological well-being as we head toward a practically interminable lifetime.
- Computational devices down-sized through via synthetic DNA, molecular computers (nano-sized processors), deployed alongside, and within cells and organs as permanent non-organic, internal adjuncts to our anatomy.
- Applications will be in the realm of nano-prosthetics.
- Nano-bots (MEMS), such as nano-sized motors will range in size from 10^{-9} (a few hundred atoms across) to 10^{-5}—the diameter of a white blood cell will course through arteries and cellular membranes to deliver drugs and destroy pathogens.
- These will carry processors equipped to communicate with the an internal server that in turn communicates to the outer world.

Shrinking Computer Operating Faster than Light

- During the next two decades, computer processors will continue to shrink to the size of a bacterium, 2 microns or micrometers (μm) long and 0.5 μm in diameter, with a cell volume of 0.6 - 0.7 μm^3 .

- Processing speeds to upwards of 10^{16} (10 trillion) operations per second, referred to as flops/sec or FPS.

- This small size will allow computers to live both within and alongside the human cell. The level of 10 trillion FPS exceeds the processing rate at roughly 10^{15} FPS of the human brain.

Future Cyborg/Telemetry

- 4G networks and successors, with gigabit bandwidth backbones, robust networking infrastructure, high-speed relays and unlimited power with recharging capabilities will serve as the medium through which feature-rich anatomical smart prosthetics operate creating a explosion of data that will be used for cyber social programming.

- Cybersecurity will become a subject alongside the list of diseases for agencies such as NIH, the CDC or the FDA, as they look for prescriptions for thwarting network attacks, fraud, and physical injury to those that have implantable technology. Concerns may take many forms, some yet to be discovered: surveillance, denial of service attacks.

- Advances in computing, communications, software, and anatomically embedded hardware will transform an individual's relationship to business and government where there will be as great a dependence on digital infrastructure as there will be for food and water.

Anticipated Effects on the Population

- Individuals with knowledge-based and skills-based enhancements will be the new expert class, cognoscenti and leaders that have a built-in ability for superior analysis, judgment and timely decisions.

- In the far future cloud computing will be how population-wide management and control will be carried out with competing paradigms vying for an individual's portfolio of enhanced abilities and health related processes, not different from how one might today choose everything from a stock broker to a physician.

- Physicians of the future will be versed in cyber-topics including algorithmic and application formulations, programming models and systems, runtime systems, middleware, and end-to-end application workflows, concerns of today's system engineers.

Transformed Medicine

- A router/modem feature embedded in the anatomy can access medical care day or night through a wireless connection.
- An expert computer process will narrowed symptoms to a range of maladies, patients will participate in their own diagnosis.
- To the extent a doctor's intervention is required, a doctor best equipped to deal with the intake diagnosis will be either contacted or a referral made by the computer.
- A worldwide grid will tune in on millions of individuals feeding searchable public health databases using a patient's anatomical data to update an expert system.
- At this stage public health service will be completely "predictive, preventive, personalized, and participatory"—, in most cases without the patient being aware of data being transmitted and collected.

Situating the Risk

- The Medical Device Security Center operates as a private partnership between Beth Israel Deaconess Medical Center, Harvard Medical School, the University of Massachusetts Amherst, and the University of Washington mission the balancing security, privacy, safety, and effectiveness for next-generation medical healthcare devices.

- In one study researchers investigated whether hackers could gain wireless access to combination heart defibrillator/pacemakers that allow doctors to monitor and adjust operating parameters remotely.

- The experiment simulated the effects of a "hacker" using a readily available commercial programmer and a software radio that can be purchased on eBay, reprogram the device, shut it down, deplete its battery, or deliver jolts of electricity that could be potentially fatal to a would-be patient.

Legal Considerations dealing with Protection of the Public

- Regulatory considerations to insure efficacy and safety, through testing, licensing, enforcement.
- Criminal law to deter crimes, such as hacking, that jeopardize safety of individuals, and the systems that "wire" classes of subscribing individuals into servers and databases.
- Civil actions that allow individuals and classes to seek redress for negligence, product liability, and warranty.

Legal Considerations dealing with Property

- Whether the systems that operate large scale networks that telemeter to individuals will be subject to business method patenting.
- Whether open sourcing of software that runs the internal and external software processes will become the preferred paradigm.
- Who will own/operate the servers and databases, pricing, access.
- What licensing restrictions will be allowed, internal software?

Distributive Justice Issues

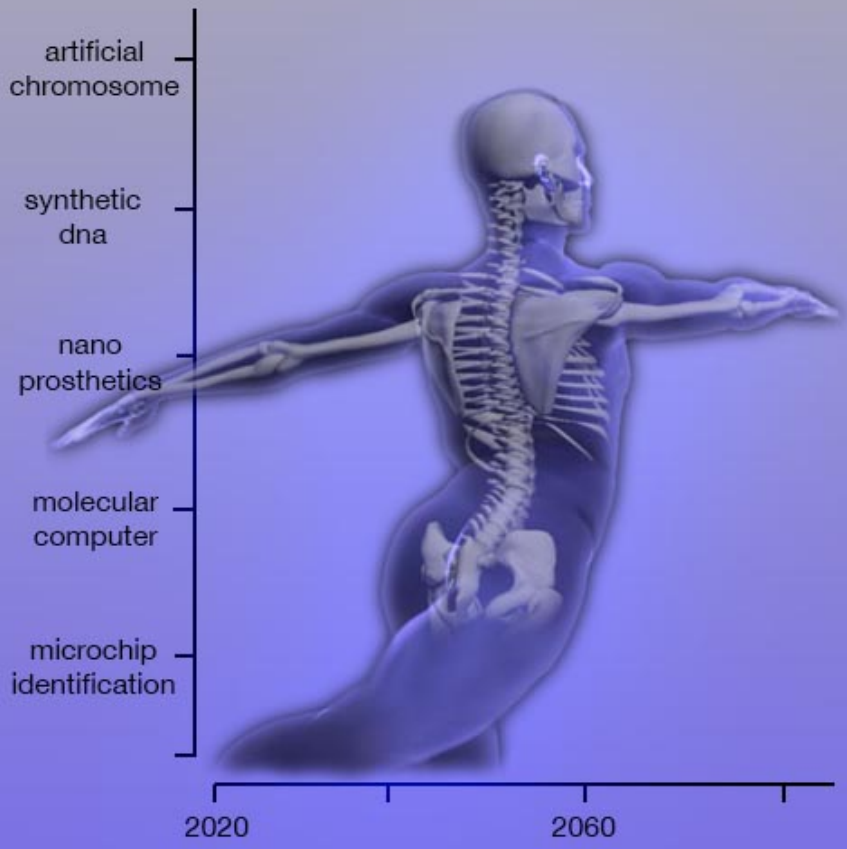
- Future computational/telemetry processing therapies might go beyond health-related purposes to provide a greater level of intellectual quickness or greater access to commercial opportunities, who will be the beneficiaries?

- Part of what will distinguish the future human population having implanted computational devices connected to the world-wide-web from a population that does not, will be the enhancements that open vast benefits for the "haves" and consequent potential detriments for the "have nots.".

- Society, the world over needs to decide if any corporation, institution, or individual should have the right to private ownership of certain forms of cyborgized property—most notably, life saving devices and selected methods of extending life and enhancing intelligence or skills.

The Techno-Human Shell

A Jump in the Evolutionary Gap



The life cycle of children born today will be driven as much by tecnology as the genes cast in their DNA backbone 3.5 million years ago

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