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Will Pervasive Computing be Manageable?

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Pervasive Computing: The promise

It's compelling:

- Ubiquitous connectivity all-the-time
  - Great for business, great for family,…
- Adapting environments
  - Great for comfort: set room temperature, turn on favorite radio station,…
- Location and context services
  - Great for emergency response, great for guidance systems,…
- Sensory services
  - Great for monitoring health and physical phenomena,…
- New forms of social interaction
  - Great for establishing new friendships and dating,,…
- …

but then there is a dark side…

Pervasive Computing: The dark side

and it's scary:

- Compromises our privacy
- Inundates us with useless bits
- Brings our world to a halt
- Destroys businesses, takes away our options
- Shortens our life

Let's see how…

Privacy is compromised

You want ubiquitous connectivity, prepare to give up privacy
- Constant tension between authentication & anonymity. Businesses want to protect themselves and provide you "personalized services".

You want location service, prepare to give up privacy
- System can now track you to within a couple of meters, even as you walk (RADAR, GPS,…).

You are now predictable!
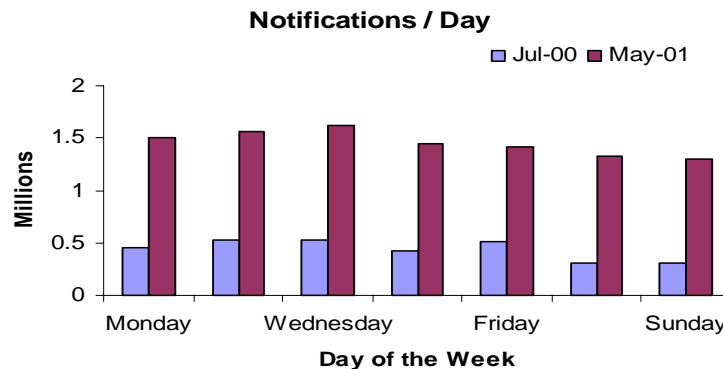- System can co-relate your location, context and behavior patterns

What if your beloved ones are being tracked? are you willing to give up your electronic connection to them for their security? their privacy?

Spam, you seen nothing yet!

Today clients outnumber servers, tomorrow servers will
  out number clients (think about sensors)

Push overtakes pull, trends are clear

160% increase in 10 months!

Notifications / Day

■ Jul-00 ■ May-01

Courtesy MSN mobile

Millions

2
1.5
1
0.5
0

Monday   Wednesday   Friday   Sunday

Day of the Week

What will happen when advertisers blast you with ads.
  everywhere you go?

Systems bite the dust

Pervasive systems will be huge and complex

- billions of processors performing trillions of operations per second
- managing the physical world, controlling sensors, actuators,…
- humans will be in the way

Errors will propagate and bring down entire regions

Hackers paradise. Multiple places, multiple ways to attack systems; viruses will propagate fast causing a meltdown

Incorrect and false information will be passed out and we won't even know about it.

Business competition will suffer

Tension between costly spectrum and unlicensed bands
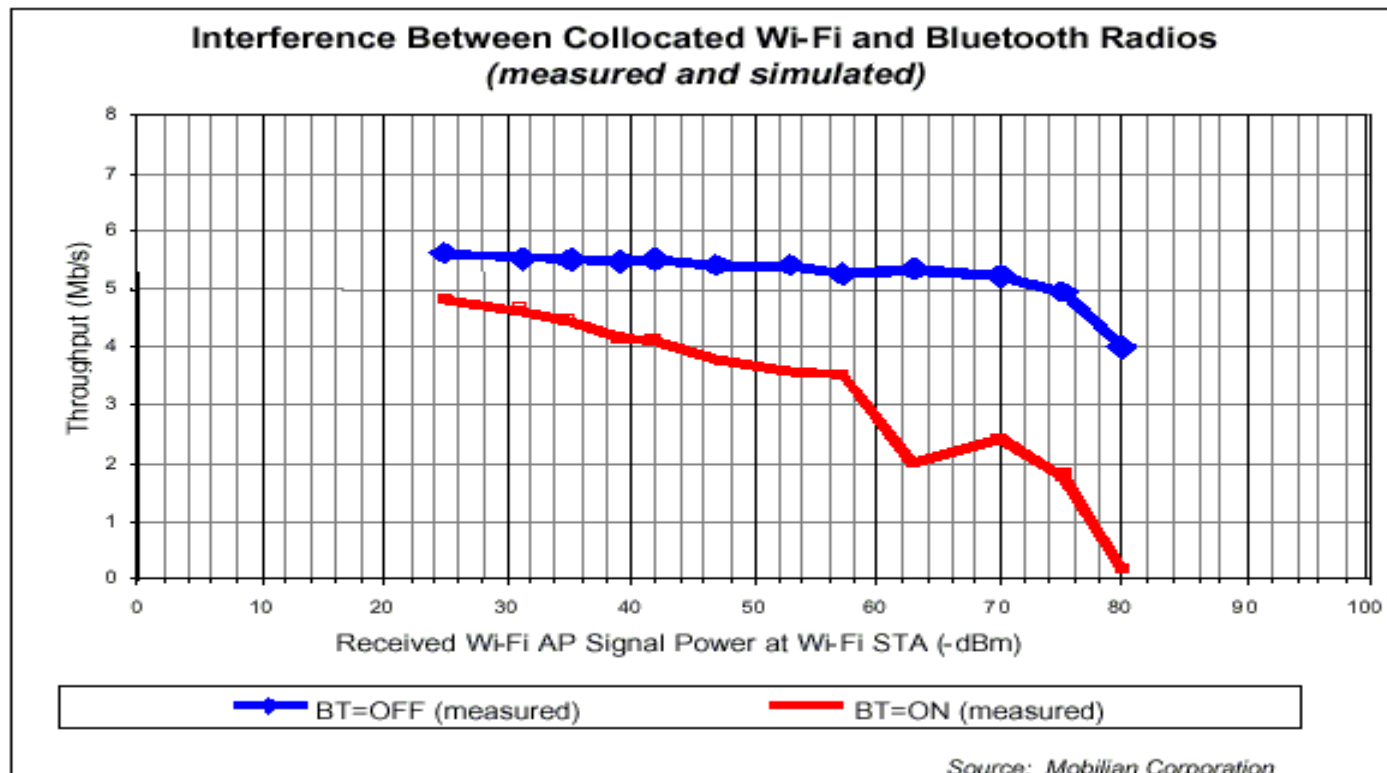
Two Models:
World is homogenous

- Whoever has money wins, whoever owns the spectrum wins. You have little choice. You always pay.

World in not homogeneous

- Spectrum is free
- Everyone has a better way of doing things, 802.11, Bluetooth, HIPERLAN, HomeRF, OpenAir,…
- Everyone has a new device: cordless phone, walkie-talkie, W-LAN, W-PAN, W-BAN, pagers, remote controls, ovens,…
- Competition between ad hoc standards – they kill each other

Colliding standards: performance degrades

Interference Between Collocated Wi-Fi and Bluetooth Radios
(measured and simulated)

Throughput (Mb/s) vs. Received Wi-Fi AP Signal Power at Wi-Fi STA (-dBm)

BT=OFF (measured) BT=ON (measured)

Source: Mobilian Corporation

Performance worsens when there are large number of short-range radios in the vicinity

Free spectrum is good but..

RF devices have to <u>co-exist</u> in the unlicensed frequency bands

Co-existence means co-located wireless devices do not significantly impact each other's performance

But they do!

- Look at Bluetooth and 802.11

What will happen when we go to U-NII band (5 GHz) – unlicensed <u>and</u> unregulated?

Our health is at risk

- Hardell and Muscat (1997) epidemiological study
    - Statistically there is greater likelihood of developing brain cancer on the side where cell phone is held, but results are preliminary
- Batz et. al. (1996) cardiac pacemaker effects
    - Digital pulsed 9000 MHz RF radiation effect defibrillators (ICDs)
- Baylor University Medical Center, Texas was effected by DTV transmissions (March 1998)
    - Consequence, wireless medical telemetry becomes primary service
- Cumulative effects of low-level modulated RF radiation over a long period of time are unknown

Our knowledge is incomplete, no conclusive answers yet!

So the dark side exists

and I repeat:

- It compromises our privacy
- Inundates us with useless bits
- Brings our world to a halt
- Destroys businesses, takes away our options
- Shortens our life because of health problems

but…

The force is with us

Dark side can be eliminated

How?

- Recognize these issues and design accordingly.
- Work together (e.g. avoid 802.11 WEP scandal….)
- Guard against human errors - build self monitoring and self managing systems
- Focus on flexibility to consumers rather than producers
- Make personal privacy and security paramount
- Build technology that promotes competition, helps the little guys (e.g. CHOICE…)
- Use the government, it can be a great ally:
  - Unlicensed is good, but unregulated?.
  - Spectrum is needed, cooperation with the world is needed

Challenge for us as researchers

Consider the following:

- Authentication with anonymity
- Customization with intelligent filtering
- Massive self-tuning, self-monitoring, self-managing, distributed reliable systems (do we know how to build these?)
- Standardization and self-regulation (of shared resources)
- Biological effects (get authoritative answers)
- Global hailing with channel switching (alleviate spectrum congestion)
- Management simplicity
- Power and cleanup (what happens when sensors die?)
- …

The question is:

How dependent do we want to be and how much are we willing to trust it?