TNG Big Tech Day 2012

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- "I tell entertaining lies (for money)"

Why you don't want to be a prophet

- Richard Wooley, Astronomer-Royal, 1956
- "Space travel is utter bilge"
- (Then Sputnik happened)
- Everybody remembers him for this!
- However ...

Why you don't want to be a prophet (part 2)

- Richard Wooley was right!

- He went on to say:

  "It would cost as much as a major war just to put a man on the moon."

- His only failure was in not anticipating political incentives for space exploration.

Caution: Black swans!

- Social pressures can rapidly change the course of technological uptake

- Nuclear power renaissance
    - Seemed likely in 2007
    - Then: global recession
    - Fukushima Daiichi melt-downs
    - Abrupt U-turn in public policy in Japan, Germany

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Some basic assumptions about the near future

- We are not going to be killed by war or natural disaster

    - Otherwise I can go home now!

- No science fictional singularity

    - HAL9000 will be disappointed

- No magic wands or nanotech pixie-dust

- ... But plenty of surprises anyway!

The near-term future

(Technocratic outlook)

It's dominated by three threats:

- energy
- climate change
- population

The near-term future

(A different perspective)

- It's not about abstractions, it's about *people*

  - Politics

  - Social pressures

  - Economics

  - Demographics

Politics

- "Democracy is the worst form of government, except for all those other forms that have been tried from time to time." — Churchill.

- Unusual prior to 1914

- Ubiquitous since 1989

- Has weaknesses

Economics

- The big story: China and India join the developed world, 1985-2035

- The untold story: Africa is following them

- 3.8 billion people shifting from under-developed subsistence agriculture to urban/industrial civilization in 50 years.

- Half the world's population!

Side-effects

- Lots of human capital is freed up

- Reduction in disease burden and stoop labour (e.g. washer-women)

- Increased intellectual development in next generation

- Human capital in developed world will increase by up to 500% in next half-century, if we manage the transition well.

Utopia or Dystopia?

- Low-inequality nations are more pleasant to live in (for most people)

- Universal development means inequality is evenly distributed

- Political outcome may depend on ubiquitous information technology

Two physical rules

- ## Moore's Law
  - Transistor count per unit area at constant price doubles every 2 years (approximately)

- ## Koomey's Law
  - Energy efficiency per MIPS doubles every 18 months

- ## Both are finite, but ...

A rough extrapolation: from 2012

- Nvidia Tegra 3 microprocessor
- 4 ARM Cortex A9 RISC processors
- Embedded GPU coprocessor
- Cache
- Power draw: ~1 watt
- Used in smartphones, tablets

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A rough extrapolation: to 2032

- 13 iterations of Koomey's law
- Equivalent to Nvidia Tegra 3 is a 100µW device
- Sensors, i/o, short range (1-10 metres) networking: up to 1mW
  - Note: Tegra 3 is 2-3 orders of magnitude more powerful than a Cray X-MP (circa 1982)
- Manufacturing cost (1 million and up): €0.10 (equivalent to 2012 RFID tags)

Power issues

- Thermal noise

- Energy needed to kick electrons around a circuit

- 2032 Tegra-3 equivalent can probably be solar-powered

  - PV cells: $150\mu W/mm^2$

What else?

- Sensors

- Storage

- Short-range networking

- Ubiquitous and invisible from human eye-level at range >1 metre

Let's make London intelligent!

- 1,750 km^2 surface area

- 7.5 million population

- Cost to saturate London with 1Tegra-3 equivalent cpu/square metre: €150M

- Cost to remove chewing gum from London's sidewalks in 2012: €190M

Getting data in and out

- 2012: Bluetooth low energy
- 200kb/s
- 10-50 metre range
- Average current draw: 1µA
- 2032: ???
- 1mb/s
- 1-5 metre range

Routing and power

- Routers in street furniture, lamps
- Use directional LEDs in street lamps to power our smart sensors
- Modulate street lights to broadcast instructions, use local cpus to pre-process data from sensor net
- In a city, you're never 10 metres away from a rat (or a computer)

Data storage

- Data storage tracks Moore's law
- End point is "memory diamond" −1 bit/atom, Avogadro's number of bits/Molar weight
- i.e. 0.5 PetaBytes in 12.5g of crystalline carbon

How much data can 1.5 billion urban sensor nodes produce?

- 1 gbit/second from sensors on each unit ~ 10^{18} bits/sec per city

- 7 tons/hour of memory diamond!

- Hence need for general purpose computing on each node to pre-process the data flow

What can we use this for?

- Price of genome sequencing is also obeying Moore's Law

- Monitor city-wide microbial genome for signs of pathogens

  (e.g. recent Legionella outbreak in Edinburgh)

- Antibiotic resistance is spreading: preventative disinfection cheaper than treatment

Other ideas

- Air quality monitoring, polutant detection
- Climatology/meteorology
- Local infrastructure monitoring (does the trash can need emptying? Is a pot-hole developing?)
- Traffic control

Urban planning

- Removal of road signs improves human attention, reduces accidents

- Can ubiquitous sensors feed local traffic hazard warnings to self-driving vehicles?

- Drop rules-based road safety protocols and instead route vehicles and people dynamically around each other

Public safety

- Is that person lying down because they're tired, or because they're having a seizure? (Call an ambulance!)

- Is that a fight? (Call the police!)

- Why is that building getting hot? (Call the fire service!)

- Intelligent streets get help faster.

Small scale uses

- Clothing that tells the washing machine how to process it

- Clothing that knows you left your phone in your pocket when you put it in the washing machine!

Farming, industry

- €0.10 solar-powered nodes imply:
- A processor for every tomato vine or apple tree
- Monitoring plants individually for sunlight, rain, temperature, signs of disease
- All manufactured products carry their own maintenance manual and recycling kit
- Nothing is too cheap to be worth monitoring

The questionable stuff

- Ubiquitous surveillance
  - Not just CCTV cameras
- RFID fingerprinting
  - No anonymity in crowds
- Individual-level tracking in real time
- Not just governments: think advertising agencies, insurers, etc.

Wrap-up

- The 1 cpu/metre urban sensor net is too cheap *not* to happen at 10 cents/cpu

- 10 cent genome sequencers, too (Moore's law: 13 iterations away from 2012)

- This stuff is roughly 20 years away

- Makes writing near-future SF *hard* ...!