Computing for the Future of the Planet

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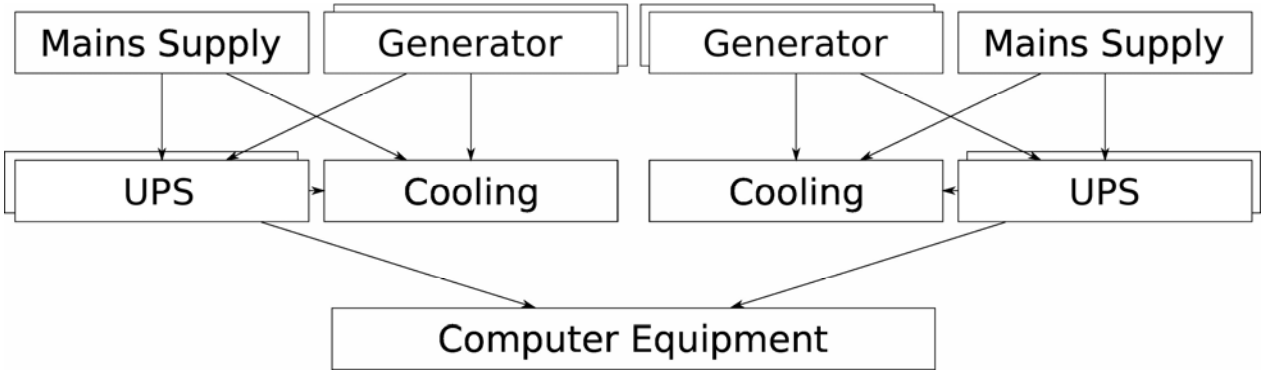
A. Hopper and A. Rice, “Computing for the Future of the Planet”, *Phil. Trans. Royal Soc. A*, Oct 2008.

Computing for the Future of the Planet

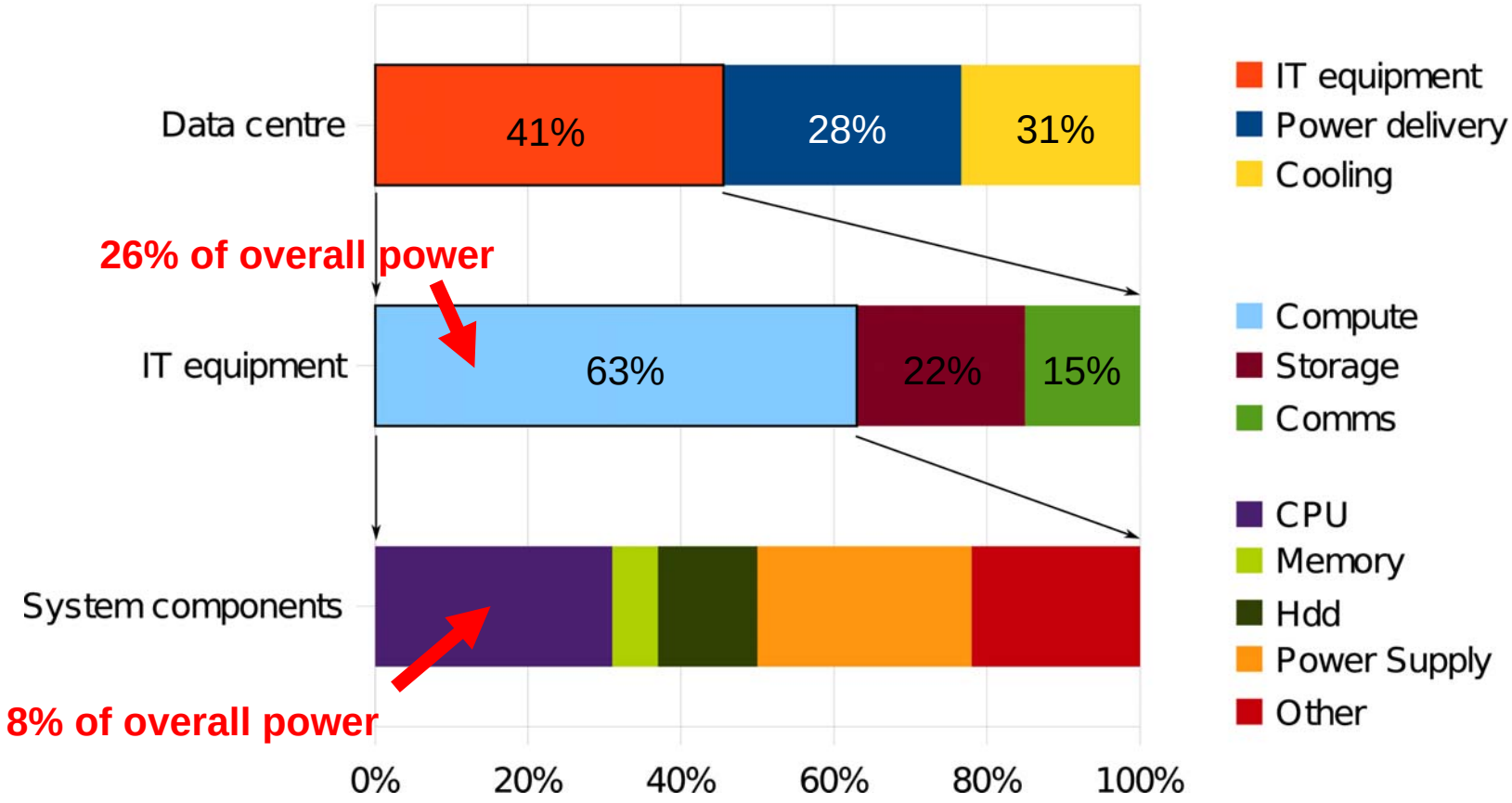
1. Optimal Digital Infrastructure
2. Sense and Optimise
3. Predict and React
4. Digital Alternatives to Physical Activities

1 - Optimal Digital Infrastructure



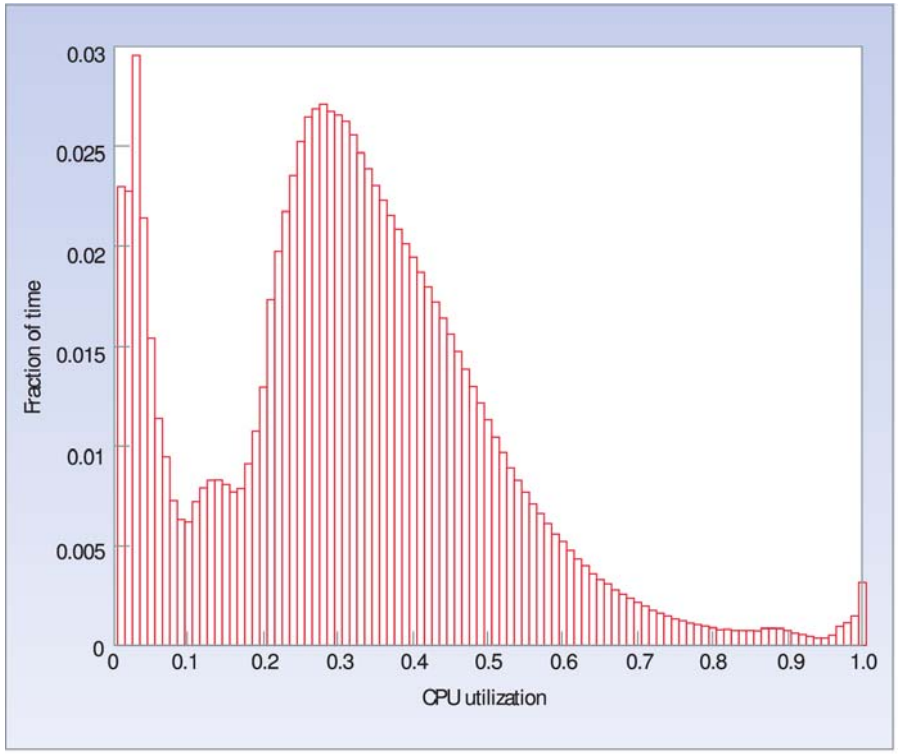
- Redundancy doubles (energy) cost of datacenter

Use of Energy by Servers



Source: Data Center Efficiency in the Scalable Enterprise, Dell Power Solutions, Feb 2007

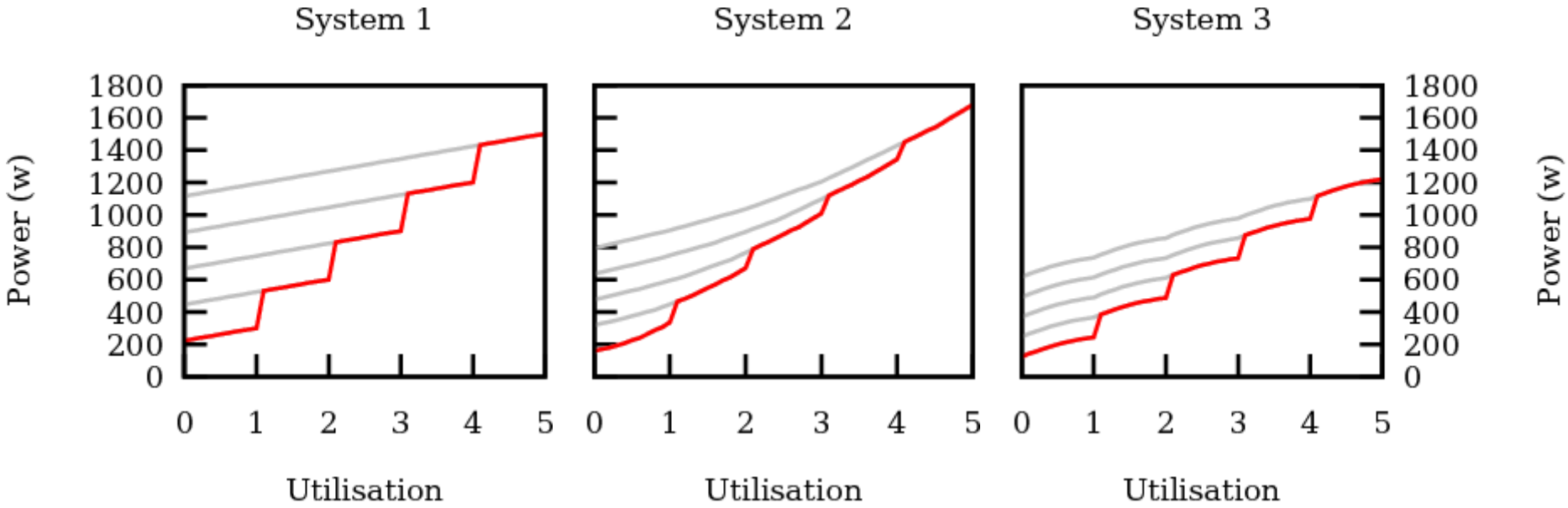
Utilisation of Servers



a six-month period.
kimum utilization,
:heir maximum

L.A. Barroso and U. Hőlzle, The Case for Energy-Proportional Computing,
IEEE Computer 40, 33–37. (DOI 10.1109/MC.2007.443.)

Power and Load – Multiple Servers



- Machines not in use are switched off
- Tasks are moved between machines
- Some tasks can be delayed
- Shape of power scaling curve less important for larger clusters
- Scale energy use with work done

Power and Load – Multiple Servers

- XEN virtualisation comes close to energy proportional computing in the SAN context
  - Tasks move between two servers in 250msec down time
    and 60sec/1Gb Ethernet,10sec/10Gb Ethernet elapsed time
- Non-interactive jobs are delay tolerant
  - Data indexing, batch simulation, climate models

Use of Remote Energy Sources

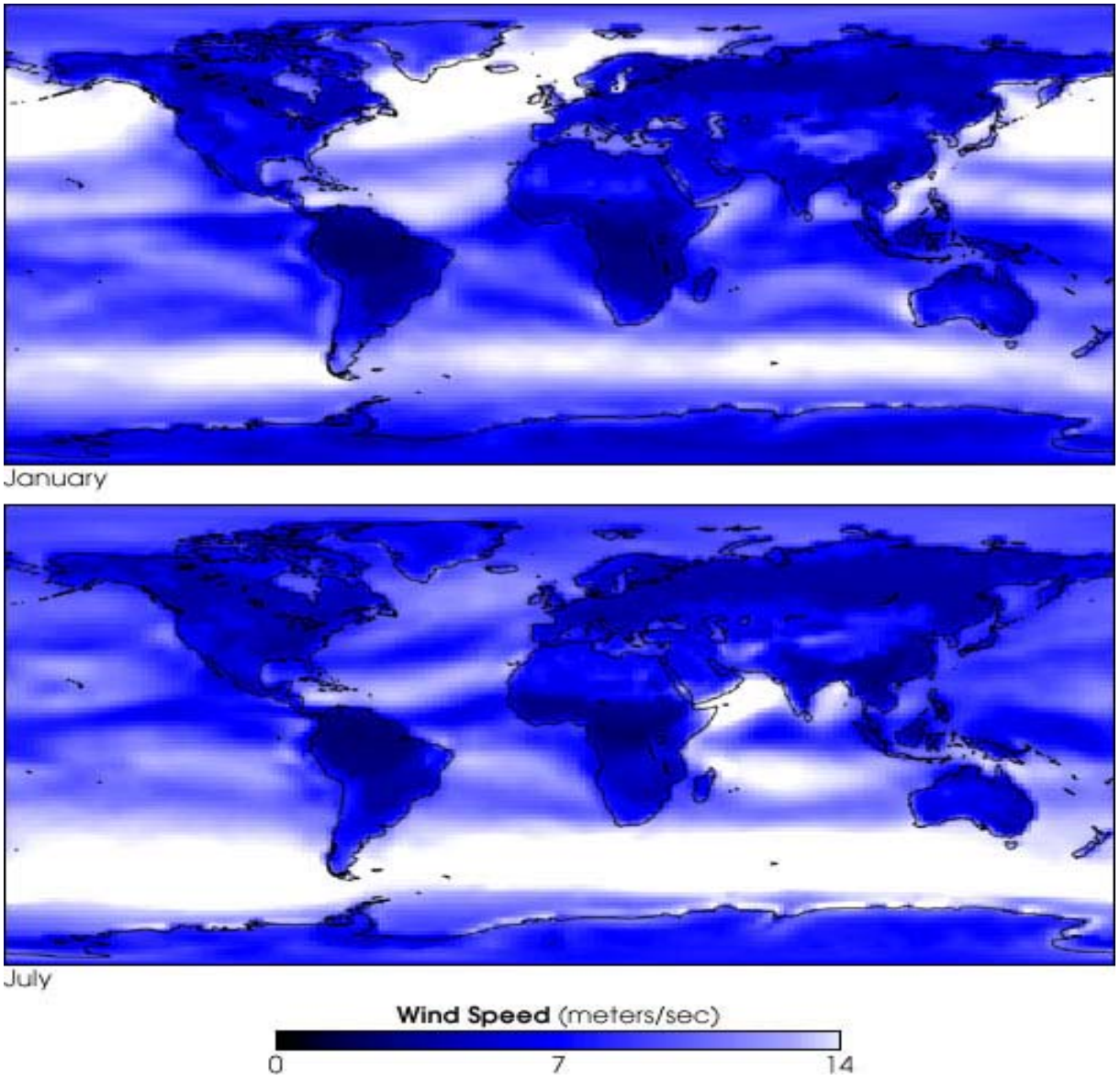
Sun

Siemens press picture

- Keep moving computing tasks to where energy is available
  - Cheaper to transmit data rather than energy
  - Use energy that cannot be used for another purpose
  - At what granularity should jobs be shipped?
  - Do we ship program, data, or both?

Wind Power Meteorology

visibleearth.nasa.gov



- What is the equivalent latency map?
- Where do we put the server farms?

The Overall Goal

- Optimal Digital Infrastructure
  - Components switched off if not doing useful work
  - Energy proportional computing and communications at all levels
  - Where possible use energy that would otherwise be lost

- Components
  - Servers / Server Farms
  - Networks
  - Workstations
  - Terminals

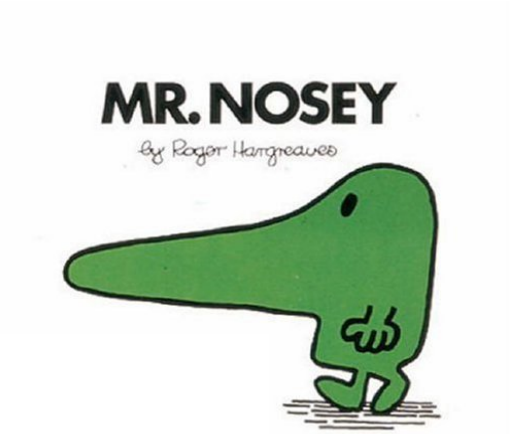
- For the first time over-provisioning and technology improvements may not save the day!

2 - Sense and Optimise

- A sensor-based digital model of the planet

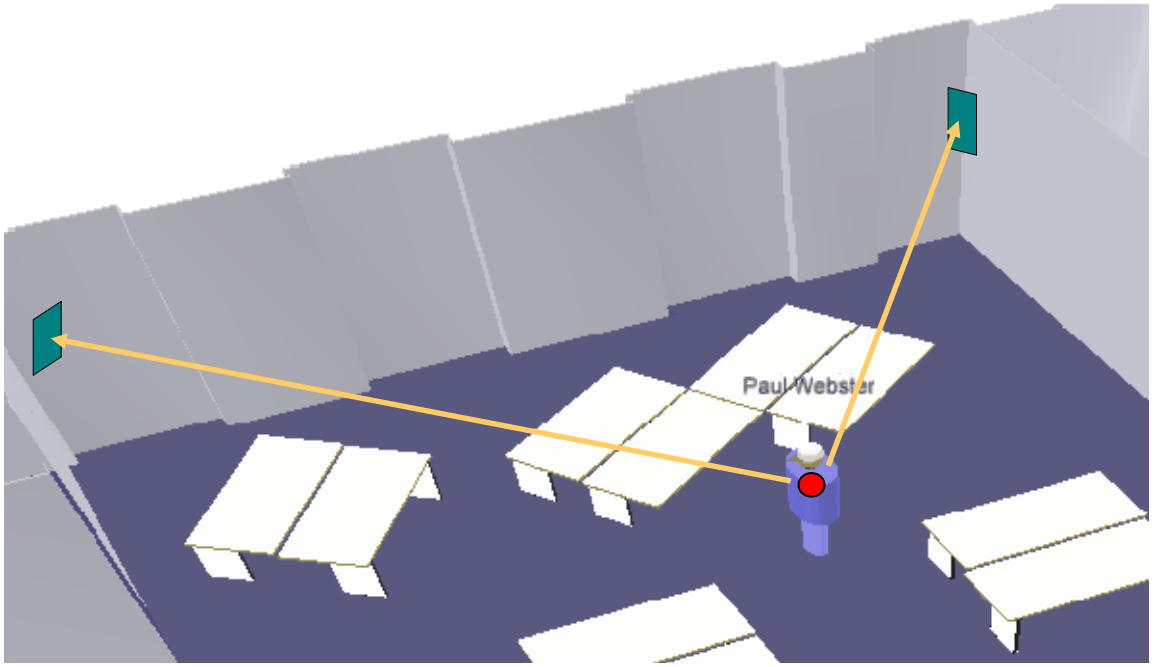
- “Googling” Earth!
- “Googling” Space-Time!

- How do we do it?
  - coverage
  - fidelity
  - scalability
  - performance
  - usefulness



Sensing Indoors

Ubisense



- Ultrawideband location system
- Measure pulse time-differences-of-arrival and angles-of-arrival

Sensing Outdoors – Use of Vehicles

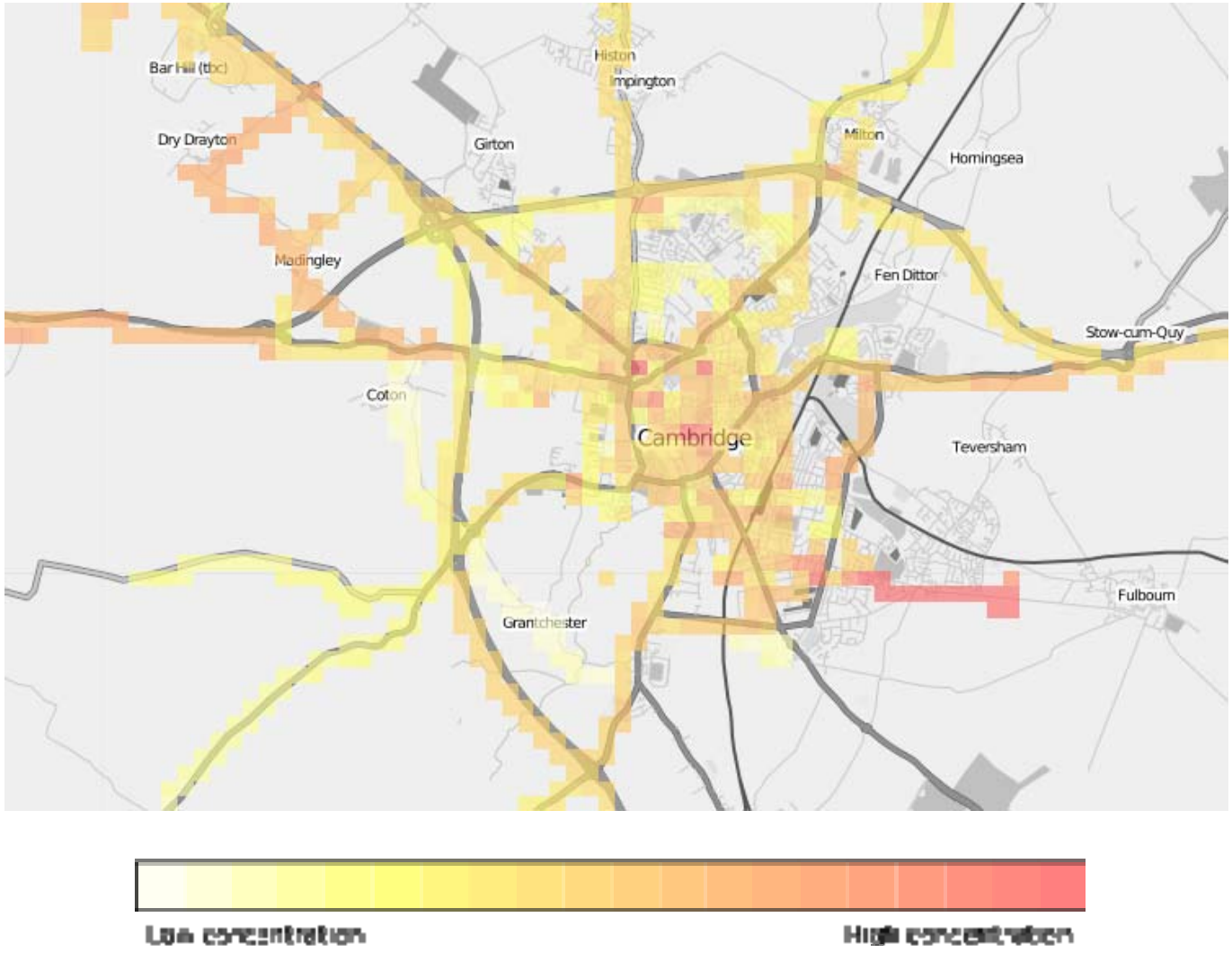
J. Davies, D. Cottingham, A. Beresford, B. Jones

- Objective
  - Take a road vehicle
  - Embed power/processing
  - Add sensors (lots!)
  - Add storage (lots!)
  - Add networks (lots!)
  - Research platform
- Future platforms
  - Mobile “phone” as sensor?
  - Federated open Global Repository?

Concept

Reality

CO_2 in Cambridge



Mapping the Spectrum

D. Cottingham

- Measured 3G signal strength
- Red is poor reception
  Blue is excellent
  Orange circles are base stations
- Results sent to the Global Repository
  - What are the standards for exchanging data?
  - How is the data marked up?
  - How does this generalise for all data?

RFeye™ DC-6GHz Node

Generating a Road Map of Cambridge

J. Davies

- GPS traces from vehicles sent to Global Repository
- Location data converted into a directed graph of the road network

More GPS readings

Fewer GPS readings

2D histogram of cells

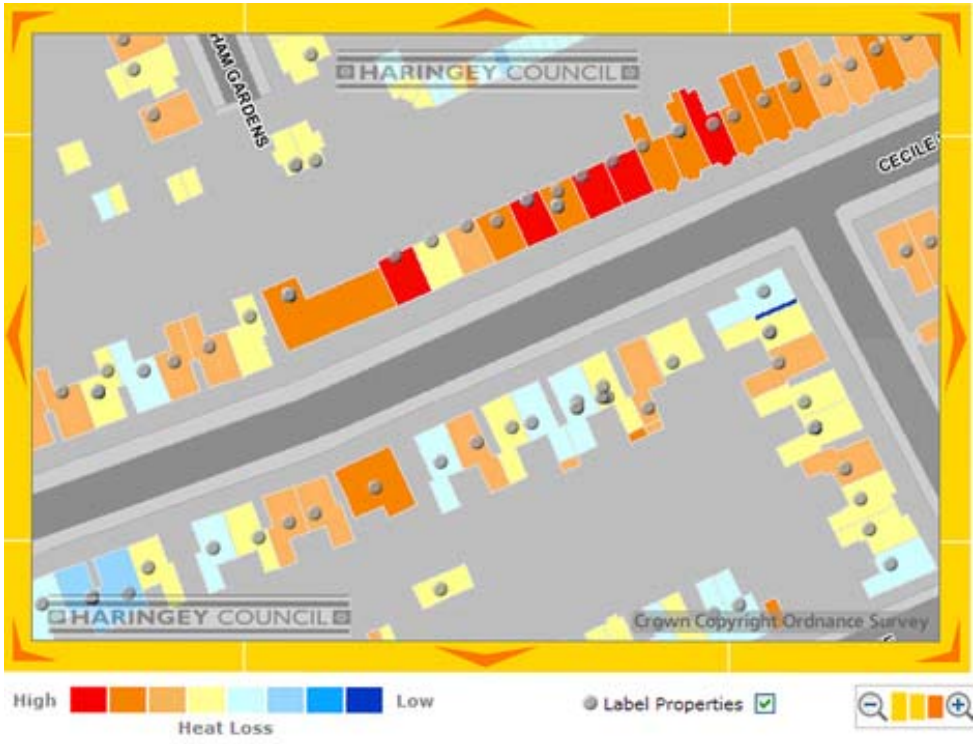
Sensing – Humans as Sensors

www.openstreetmap.org

- Openstreet map is an example of human sensing
  - Pubs, post boxes, potholes, etc
- Reward for content creation?
- Enticing and wealth creating for developing world?

Thermal Maps

www.seeit.co.uk/haringey/Map.cfm



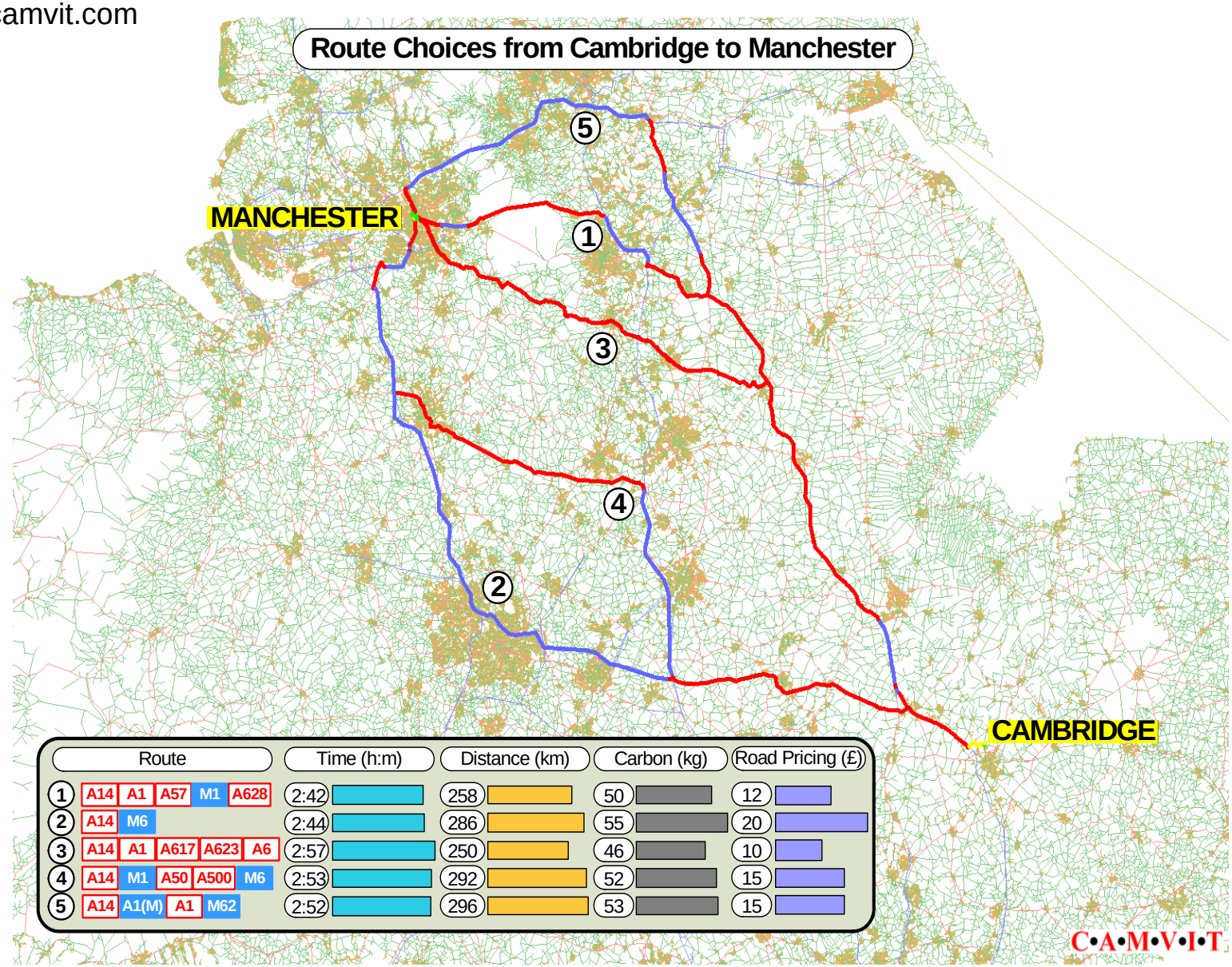
- London Borough of Haringey used aerial survey to generate thermal images
- Should this be a real-time global service like GPS?
- What applications would be written if data was free?

Personal Energy Meters

- Collect information about individual energy consumption (direct and indirect)
- Present itemised breakdown
  - travel, heating, water usage, transportation of food, etc
- Use World Model
  - upload own energy use to help digital optimisation
  - download energy profile of devices and goods
- Lots of lovely computing problems!
  - measurement, indexing, caching, event-delivery, prediction, use of social networking, security, privacy, correctness, etc

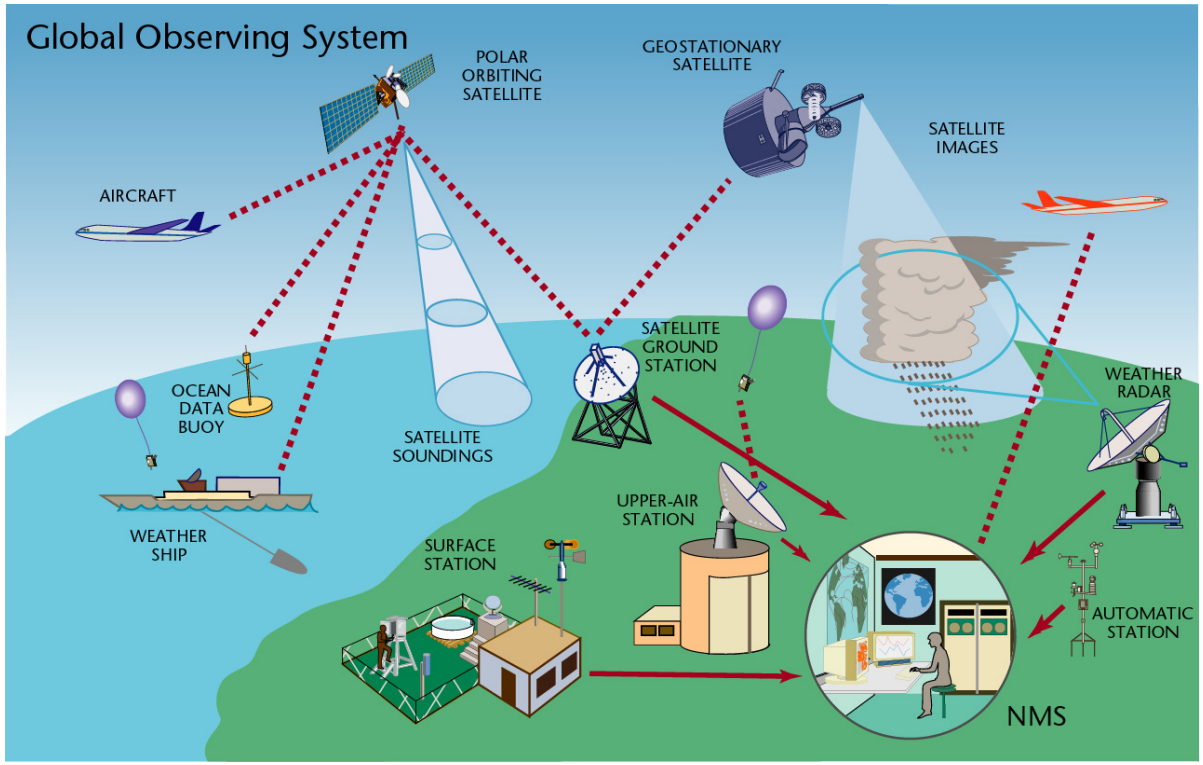
3 - Predict and React

www.camvit.com



	Route	Time (h:m)	Distance (km)	Carbon (kg)	Road Pricing (£)
1	A14 A1 A57 M1 A628	2:42	258	50	12
2	A14 M6	2:44	286	55	20
3	A14 A1 A617 A623 A6	2:57	250	46	10
4	A14 M1 A50 A500 M6	2:53	292	52	15
5	A14 A1(M) A1 M62	2:52	296	53	15

Global “Scientific” Computing



- Requirements
  - Accurate and correct model
  - Algorithm separated from implementation, verified code
  - Shared data, up to date data
  - Deadline driven computation (part of a control loop)
  - Energy scaleable computer power

4 - Digital Alternatives

GuardianUnlimited network

- Move bits rather than people or products
  - iTunes, Tesco Online, etc
- Good news or bad news?

Shift to Cyberspace?

- Can we construct a digital world in which we can conduct our lives?
  - on a ultra-cheap open platform
  - using miniscule power
  - fed with sensor data from the real-world
  - accessible to every human
- Scaling up virtual worlds is a challenge
- Key to wealth creation in developing world?