Scientific Cloud Computing – Environmental Aspects of Network Infrastructure

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Format

- Me, my research
- Performance measurement
- Standard methods
- App stores
- Green IT and energy
- Cloud performance & behaviour

About me

- PhD – Performance measurement of network protocols
- Measure OSI and TCP

Research

- Network Management
  - SNMP performance and behaviour
  - Training for network managers
  - Studying manager reaction
  - SNMP overheads
    - Tradeoff between effective management and network load

Performance

- Simulation of Wireless LAN
- Modelling WLAN architecture
- Performance of mobile agents
- Performance of MANETs
- Thin vs. thick client

Standards

- For comparison, must use same:
  - Metrics
  - Methods
- Allows measurement to be
  - Repeatable
  - Verifiable
  - Comparable
- Qu: What to measure?

What to measure?

- Speed, reliability, accuracy
- Speed
  - Connection time
  - Data rate
  - Disconnect time
- Reliability
  - Successful connection
  - Complete data transfer
- Accuracy
  - Correct connection
  - Correct data transfer

Measuring software

- Speed of operation
- Reliability
- Accuracy
- Energy use?

Off the shelf apps

- “App store”
- Code reuse
- History – more features in each new release
- Code sharing / reusable modules
  - Reduced knowledge of internal structure
- E.g. Two methods to do similar task
- Option A is very small lower energy cost (<1%)
- Option B has “better” features
- If all choose B - …

Green / sustainable IT

- 2% of GHG
- 10% (and rising) of typical organisation's energy
  - Later data suggests 20%+
- Consider where energy is used
  - And where savings can be made

Some numbers – data centres

- Energy consumption of data centres grew 63% in 2012 (Datacentre Dynamics)
- Data centres accounted for 14% of ICT carbon dioxide emissions in 2007
  - Projected to be 18% in 2020 (The Climate Group, 2008)
- 1.2 zettabytes of stored digital information (Greenpeace, 2011)
- “If the cloud / internet were a country”
  - 5th in electricity consumption
  - (Greenpeace, 2010)

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Some numbers – end systems

- 1.78 bn PCs and 1.82 bn units of browser equipped mobile devices in use by 2013 (Gartner, 2010)
- By 2020, 50% of the world's population will own a mobile phone (Climate Group, 2008)
- 4 bn cellular subscriptions worldwide at the end of 2008, 5 bn by 2011 (ITU, 2010)
- 50 bn internet-connected devices by 2020 (Ericson, 2010)
- 91% of users use their phones to access social networking sites vs. to 79% of desktop users (Read Write Web, 2010)
- Social networks overtook search engines

  for UK Internet visits in May 2010

  (O'Hear, 2010)

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Digression – people

- Changing behaviour
  - Switch off after use
  - Print management
  - Work patterns

Energy consumption

- PC – network – server
- Qu: What can be done?

What can be done

- Desktop
  - Power management
- Server
  - Virtualisation
  - Physical layout
  - Environmental control
    - Room temp
    - Cooling units
  - Problem is number of servers
  - Economy of scale
    - Cloud

Cloud - Some Definitions

- Poised to succeed where other [efforts] have failed
  - Technology review
- The fastest growing part of IT
  - Stanford University
- a game changer … disrupting traditional software and hardware business models by disrupting how IT service gets delivered
  - Cloud computing expo
- Threatening the business model of Indian IT outsourcing
  - Financial Times 17 August 2009

Or …

- A trap; worse than stupidity
  - Richard Stallman, GNU founder
- Fashion-driven; complete gibberish
  - Larry Ellison, founder of Oracle
    - Both quoted in Guardian 28/9/08

65 years of development?

- “I think there is a world market for maybe 5 computers”
  - Widely attributed to Thomas J. Watson, Chairman of IBM, speaking in1943
- In 2008, the number of PCs *in use* was
  - 1 billion (Gartner group)
- So what happened?

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In the beginning

- Complex, difficult to operate
- Large, expensive
- Data storage?
  - mercury delay
  - magnetic drum
  - Reserved for important purposes

- Pic: Jesty and Peter Jesty Consulting

1981 -The PC

- Possibly the first “game changer”
- Personal computer power
- Personal storage
  - Cassette tape
  - Floppy / hard disc
  - CD
  - Memory stick
- Provided you don’t lose it!

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1980s / 90s - the network

- Computers able to communicate with each other
- Sharing data and programs
- For safety, provide backup “server” storage
- Servers become larger in capacity
- For business use, the “workstation / server” model develops
- For home use, connect to the internet, but retain local disk / memory stick … storage

2009 - Typical office environment

- Desktop PCs
- Shared servers holding most programs and data, located in a “server room”, administered by technical staff
- Server hard disks estimated to be
  - 10 – 15% “full” at any time
- Wasteful of storage, money and energy
  - 10% of the UK’s electricity used to power “IT”
  - Some estimate 20% of “public sector IT”

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Something must be done

- Smaller units?
  - Little saving in cost and energy
- Fewer units?
  - Virtualisation
  - Running > 1 “logical” server on the same “physical” system
  - Effective in reducing cost and power use
- Simpler desktops
  - If storage (and computing) done by the server more efficiently, no need to have a high-spec desktop

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So..

- The desktop becomes “just” a terminal
  - Or a mobile; a games console; …
- All the work is done by a server
- All the data is stored on a server
- If these servers are
  - Shared
  - Located “somewhere in the internet”
  - They can be accessed without needing to know their actual location
  - Users can access (and pay for) the computing they use, as they do for other utilities
- We have Cloud computing

Advantages

- Lower equipment first costs
- Lower support and maintenance costs
- Easier access to software and shared data
- Greater ability to share your data
- Access to *your* data wherever you are, on any suitable device

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Disadvantages

- No control over data storage / security
- Lack of flexibility to install new software
- Need to negotiate with external supplier
- Reliance on the network
  - And little chance to influence that
- Geo-political issues
  - Governed by the laws of the country where the server is physically based

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What about the network?

- Local switch (wired / wireless)
- Corporate switch / gateway
- Provider edge switch
- Core router(s)
- Core network (fibre)
- Devices always “on”, with limited power reduction capability
- Increasing sharing of resource, more difficult to determine “your” energy use

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Cloud Savings?

- 55% plan to use Software-as-a-service (SaaS) to reduce energy consumption (Semantec, 2009)
- The mass adoption of cloud computing services like social networking *can* cut carbon emissions *in ways that are not possible to predict* (The Climate Group, 2008)
- Adoption of cloud computing will lead to a 38% reduction in worldwide data centre energy expenditure by 2020. ... cloud computing will reduce greenhouse gas emissions by 28% from 2010 levels (Pike research, 2010)
- Companies can save between 30-90% of their energy consumption and carbon footprint on on-premise applications if they move to the cloud (Accenture, 2010)
- Cloud computing business users use 91% less energy than businesses that use on-premise applications (Nucleus Research, 2010)

However ..

- If and only if
  - local resource saved > cost of network resource used
- For Scientific / HPC
  - More intensive resource use
  - Within facility **and** across the network
  - Within
    - parallelism / data centre methods
  - Cross-Network
    - Data transfer and storage

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Measurements

- Data centre – PUE etc.
  - See our current JISC data centre metering project
- End user – plug in meters;
  - Plus informal notification (it stops working!)
- Network measurements
  - Power, cooling within wiring closets
  - Distributed across the campus, country, globe
  - Average 10 – 15 hops

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Measuring

- Units
  - Within processors
    - Flops -> flops / W (Green500 list)
  - For data
    - Bits / W (or bytes / W)
    - Watts / bit (ECR initiative)
- Process
  - Benchmarking?
  - Simulation / estimation?
  - Live measurement?

A proposal

- An integrated energy measurement system
- Utilising appropriate measurement methods
  - Research needed to determine these
    - Scope, units and location
- Energy to be key part of the use model
  - Hence communicated with the user
  - … and billed!

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Requirements

- Agreement on measurement units
  - Bits / W
- Process / reporting
  - Live measurement + estimation
  - Negotiation (SLA)
  - Monetarisation
    - Bits / W -> €, £, $
  - Control
    - User choices
    - Management action

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Conclusion

- Cloud *may* be energy efficient
  - Under certain conditions
- Require a management and use model
- Without measurement
  - Cannot verify or operate the system effectively
  - Cannot manage operating load to deliver savings

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