The role of cloud computing, telepresence and telecommuting for reducing energy usage

-Dr. Anders S.G. Andrae, Huawei, Nov. 1, 2013
Outline

- Experience of Huawei
- Introduction to energy consumption of ICT, Entertainment&Media and cloud
- Cloud computing
  - micro implications
  - macro perspectives
- Implications for energy saving – micro and macro
  - Telepresence
  - Telecommuting
- Summary
- Next steps
Experience of Huawei

Life cycle assessments performed
- Radio Base Stations
- All sorts of mobile phones
- Tablets
- Metals
- FTTx Networks
- Radio Access Networks
- Cloud Computing Networks
- Quick LCA method developed

Sector analysis performed
- ICT+Entertainment&Media (E&M) Sector with a defined scope
Energy (≈electricity) usage by ICT and cloud

- Cloud computing is readily available internet computing for many services (software, storage, computing, etc).

- Energy saving is not main purpose of cloud which is mobility, availability, cost, security, scalability.

- Digital technologies will all move into the Cloud more or less via wireless transmission.

- The scope of "Cloud" needs to be defined for each analysis of energy usage.

- Public cloud and Private cloud.

- Energy usage of cloud is correlated to private/public + low/high frequency of use of service.

- "Cloud Computing" used ≈700 TWh in 2012, i.e. ≈40% of ICT and E&M electricity.
Traffic types: ICT and cloud

Increasing Traffic Trends:

- Mobile data share of access
- Fixed+WiFi share of access
- "Within and between data centers" share of global data center
- wireless cloud increasing
Emerging wireless cloud

Shares of Access traffic
- Mobile Data
- Fixed Data
- Fixed + Wifi

Shares of Global Data Center IP traffic
- Access ("Data-center-to-user")
- Within and between Data centers
Trends for global IP traffic and energy

Trend is very clear. Data created is growing steeply, however, the related energy usage is under control until 2020.

Suppliers, Operators and Research Community work together.
>32% annual improvement (AI) of energy/traffic needed to reduce energy as mobile traffic grows 51x

EE = energy efficiency

• Mobile: 4G and SDN radio access solutions will overall become as efficient as WiFi solutions
>12% and 19%, annual improvement of energy/traffic expected from measurements of mixed networks.

Semi-empirical case study shows that large improvements ≈35% AI could be possible

High utilization of mobile networks is key to their energy efficiency. The Cloud is accessed more and more via mobile access.
Energy consumption by ICT+E&M: Theory

Observations on this projected 2017 data:
• Direct consumption by devices is less than 1/3 of electricity; compared to 1/2 in 2012.
• Data centers + networks combined will represent 1/2 of electricity usage
• LCA (Manufacturing Upstream) remains approximately at the same level of contribution

http://vmserver14.nuigalway.ie/xmlui/bitstream/handle/10379/3563/CA_MainArticle14_all-v02.pdf?sequence=4
Micro: Cloud computing

Case study: Physical Desktop (PD) vs Virtual Desktop (VD)

Generally there are two types of office users: PD and VD users

PD use the Desktops as Servers

VD users instead use Servers in the Data Center. VD use Thin Clients to connect.

This case study represents a private cloud using wired transmission.

Wireless transmission might render different conclusions.
End-user devices: Desktops+Screens+Mouses+Keyboards with Server/Applications/Storage/Firewall all

Private Network Equipment: Switches, Access Gateway

Intranet
Micro: Cloud computing – VD scope

End-user devices: Thin Clients+Screens+Keyboards+Mouses

Private Network Equipment: Switches, Access Gateway

Intranet

Data Center: Cabinets, Batteries, UPS, Cooling Equipment

Virtual desktop

Switches, Storages, Firewalls

Data Center

APP, OS, VM

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Virtual desktop

Switches, Storages, Firewalls

Data Center

APP, OS, VM
## Micro: Cloud computing cont.

<table>
<thead>
<tr>
<th>End-User Equipment type</th>
<th>PD [#]</th>
<th>VD [#]</th>
<th>Mass [kg/#]</th>
<th>Power [W]</th>
<th>Life [years] time</th>
<th>Annual electricity [kWh]</th>
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<tbody>
<tr>
<td>Keyboards</td>
<td>488</td>
<td>488</td>
<td>1.25</td>
<td>-</td>
<td>3</td>
<td></td>
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<tr>
<td>Mouses</td>
<td>488</td>
<td>488</td>
<td>0.12</td>
<td>-</td>
<td>3</td>
<td></td>
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<tr>
<td>Thin Clients</td>
<td>0</td>
<td>488</td>
<td>0.605</td>
<td>&lt;15.2</td>
<td>5</td>
<td>17,421</td>
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<tr>
<td>Screens</td>
<td>488</td>
<td>488</td>
<td>5.1</td>
<td>Lenovo tool</td>
<td>3</td>
<td>22,936</td>
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<tr>
<td>Desktops</td>
<td>488</td>
<td>0</td>
<td>11.3</td>
<td>--”--</td>
<td>3</td>
<td>139,568</td>
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# Micro: Cloud computing

<table>
<thead>
<tr>
<th>Data Center Equipment type</th>
<th>PD [#]</th>
<th>VD [#]</th>
<th>Mass [kg/#]</th>
<th>Power [W]</th>
<th>Life [years]</th>
<th>Annual electricity [kWh]</th>
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</thead>
<tbody>
<tr>
<td><strong>Servers</strong></td>
<td>0</td>
<td>2</td>
<td>10 (est.)</td>
<td><strong>Blade Servers</strong></td>
<td>5</td>
<td><strong>Blade Servers</strong></td>
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<tr>
<td><strong>-Blade Servers</strong></td>
<td>10</td>
<td></td>
<td>20 (est.)</td>
<td>90-130 (CPU model)</td>
<td>5</td>
<td>16000</td>
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<tr>
<td><strong>Storages</strong></td>
<td>0</td>
<td>2</td>
<td>90 (est.)</td>
<td>650</td>
<td>5</td>
<td>11120</td>
</tr>
<tr>
<td><strong>Switches</strong></td>
<td>0</td>
<td>4</td>
<td>10 (est.)</td>
<td>91</td>
<td>5</td>
<td>3108</td>
</tr>
<tr>
<td><strong>Firewalls</strong></td>
<td>0</td>
<td>2</td>
<td>10 (Eudemon 1000E Series Firewall)</td>
<td>75</td>
<td>5</td>
<td>1306</td>
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<tr>
<td><strong>Batteries</strong></td>
<td>80 (50Ah12V)</td>
<td></td>
<td>16.75</td>
<td>8</td>
<td></td>
<td>Annually 10 batteries</td>
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<tr>
<td><strong>UPS</strong></td>
<td>1</td>
<td></td>
<td>105-430</td>
<td>20</td>
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<td>Annually 0.05 UPS</td>
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<tr>
<td><strong>Cabinets</strong></td>
<td>2</td>
<td></td>
<td>100</td>
<td>10</td>
<td></td>
<td>Annually 0.2 Cabinets</td>
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<tr>
<td><strong>Air Conditioners (20kW-40kW)</strong></td>
<td>1</td>
<td></td>
<td>332-388</td>
<td>10</td>
<td></td>
<td>Annually 0.1 AC</td>
</tr>
</tbody>
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# Micro: Cloud computing

<table>
<thead>
<tr>
<th>Private Network Equipment type</th>
<th>PD [#]</th>
<th>VD [#]</th>
<th>Mass [kg/#]</th>
<th>Power [W]</th>
<th>Life [years] time</th>
<th>Annual electricity [kWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switches</td>
<td>488/40=12.2</td>
<td>488/40=12.2</td>
<td>10 (est.)</td>
<td>91</td>
<td>5</td>
<td>9479.4</td>
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<tr>
<td>Gateways</td>
<td>1</td>
<td>1</td>
<td>10 (est.)</td>
<td>70 (est.)</td>
<td>5</td>
<td>574</td>
</tr>
<tr>
<td>Cables</td>
<td>Cut-off</td>
<td>Cut-off</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VD is 36% lower than PD for CO2e and 43% in electricity

Typically micro cloud computing energy analyses show >50% reductions in CO2 emissions

Overheads energy could be noticable
Micro: Cloud computing

VD is advantageous to PD mainly due to the less impact of end-user devices.
VD is advantageous to PD mainly due to differences associated with the Desktop and Thin Clients life cycles.
With PUE 1.7 the cooling electricity became the highest individual contributor. 

\[(1.7 - 1) \times \text{electricity consumption in data center} = 22,100 \text{ kWh/year}\]
Green Power \( (\approx 0.1 \text{ kg CO2e/kWh}) \) → VD CO2e per user reduced from 270 to 211 kg CO2e/user/year.

The Physical Desktop less chance shifting to Green Power as it is more confined to grids?
Micro: Cloud computing

Virtual Desktop Huawei World, 488 users

Screen (Monitor) Production becomes the highest contributor.
Macro: Cloud computing

- The network connectivity demands of billions of devices + growth in Cloud based services → increase in ICT+E&M related energy consumption → more eco-impact?

- Reinforcing loops encourage increased data consumption and the number of devices → cloud computing increase overall energy usage

- Public cloud:
  - Increase driven by consumer behaviour which is difficult to predict
  - >4/5 of cloud IP traffic and grows faster than private cloud

Browne, Jones, Compston 2012
Macro: Cloud computing

- Consumer (Public)
  Cloud traffic will drive the demand of data
- General technologies → stronger rebound

Trends for Data Center IP traffic

Cloud Traffic share of Total traffic

- Cloud Based
- Non Cloud Based
- Public Cloud
- Private Cloud
Macro: Cloud computing rebound

The rebound effect $R$ (%) is defined as $R = (Ex - Re)/Ex$. $Ex =$ expected decrease. $Re =$ Real decrease

A rebound effect of 40% means that e.g. the electricity usage decrease 60% of the expected decrease, $(100 -40)/100\% = 60\%$

**VD examples:**

Initially year 1 VD use 120,8 MWh electricity.

Electricity efficiency improvement is 5% per year.

After 4 more years

Rebound effect **not considered**; $120,8 \times (1 - 0,05)^4 = 98$ MWh.

Rebound effect **10%**; $120,8 \times (1 - 0,05 \times 0,9)^4 = 100,5$ MWh.

Rebound effect **100%**; $120,8 \times (1 - 0,05 \times 0)^4 = 120,8$ MWh.

Rebound effect **130%** (backfire); $120,8 \times (1 - 0,05 \times -0,3)^4 = 128,2$ MWh.
Micro: examples of sensing in homes

- The Netherlands:

  \[ e_{\text{invested}} = e_{\text{saved}} \] is dependent on type of Home Energy Management System and duration of use

- UK:

  - For a home with a relatively large number of ICT devices, the addition of home sensing can increase the emissions and energy by >10%
Micro: Telepresence savings

- **5 meetings/employee/week**
- **2 hours/meeting**

→ ~90% reduction in CO$_2$ emissions due to avoided travel

Important to place the absolute saving in context with other emissions.
Micro: Telecommuting savings

- 2 days home work/week
- 50 km one-way
  → ~25% reduction in CO₂ emissions due to avoided travel

[Bar chart showing CO₂ emissions for Office work and Telecommuting.]
Macro: Travel is expected to increase

- Increasing (public) car use in developing countries + the global growth in (public) air travel \(\rightarrow\)
- A rapid rise in \(\text{CO}_2\) emissions
The electricity, CO2e and other footprints caused by the ICT+E&M Sector is growing slowly but steadily

- The end-users devices show good improvements per unit for the use stage
- The driver of the ICT+E&M Sector footprint is moving to the Networks and Data Centers
  - Energy Trend for Data Centers similar to Core&Metro Networks
- Wireless: Mobile Networks (energy challenge) and WiFi are growing fed by cloud applications
  - Cloud computing is highly recommendable for private (business) cloud with wired transmission
- Overall the energy usage related to cloud will increase
  - Rebound effects can be controlled better for private (office) cloud applications...more difficult for public cloud
- Telepresence and telecommuting will decrease businesses financial and energy costs
  - Still overall the global travel is expected to increase anyway

SUMMARY
Next steps

- Policy
  - Promote data centers with GreenPower
  - Expected global travel increment not yet correlated to smart ICT solutions?
  - The whole nation footprint has to be evaluated in order to detect rebound effects (1st, 2nd, 3rd order) of more ICT technology
  - Promote smart ICT Solutions..but make integrated assessment

- Empirical Methodology
  - Framework which integrates
    1. System expansion
    2. Consequential LCA
    3. 1st, 2nd, 3rd order rebound effects
  - more precise guidance for specific situations