Thinking beyond the network & Lessons from the not-so-past

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NSF Future Wireless Cities
Natural evolution
IoT varies in communication needs

sensors

actuators

1/hour 1/minute 1/second 10/second

CPS

IoT
IoT: more than programmable light bulbs

- Public sensors & actuators
- Semi-private
- Private
Lessons on our way to wireless cities

- We don’t predict applications well
- Resource constraints are dollar constraints
  - they mainly offer temptation to do QoS research (again)
- Internet lesson #1: L3 is forever, but don’t get too attached to L1/L2
  - Cross-layer optimization may make for better papers, but confuse developers
- Security usability is more important than security sophistication
  - Cliché: Internet not designed for security
  - Network security is about naming
"Ongoing problems continue to threaten NextGen’s costs and timeline."

"[NTSB] has advocated for some form of positive train control for more than 45 years."

allocated in 1999

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Design for 20 years

Mobile Network Technology Lifecycles (North America)

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We need research for opex, not (just) capex

<table>
<thead>
<tr>
<th>Company</th>
<th>Revenue</th>
<th>Capital expenditures</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comcast (US) [3Q14]</td>
<td>$11.04B</td>
<td>$1.644B</td>
<td>14.9</td>
</tr>
<tr>
<td>Telekom (DE) [3Q14]</td>
<td>€15.6B</td>
<td>$2.58B</td>
<td>16.5</td>
</tr>
<tr>
<td>Safaricom (KE) [H1FY15]</td>
<td>Ksh 79.34B</td>
<td>Ksh 12.37</td>
<td>15.5</td>
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</tbody>
</table>
### Generational surprises in cellular networks

<table>
<thead>
<tr>
<th>Generation</th>
<th>Expectation</th>
<th>Surprise</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G</td>
<td>better voice quality (&quot;digital!&quot;)</td>
<td>SMS</td>
</tr>
<tr>
<td>3G</td>
<td>WAP</td>
<td>web</td>
</tr>
<tr>
<td>4G</td>
<td>IMS</td>
<td>YouTube, WhatsApp, notifications</td>
</tr>
<tr>
<td>5G</td>
<td>IoT (low latency)</td>
<td>?</td>
</tr>
</tbody>
</table>

underestimated cost and fixed-equivalence as drivers
# Lessons, in brief

<table>
<thead>
<tr>
<th>Experience</th>
<th>Lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>VoLTE, IMS</td>
<td>avoid complexity</td>
</tr>
<tr>
<td></td>
<td>avoid layer entanglement</td>
</tr>
<tr>
<td></td>
<td>plan intercarrier interfaces</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>don’t trust the RAN/AP</td>
</tr>
<tr>
<td>disaggregation of functions</td>
<td>clear &amp; simple interfaces</td>
</tr>
<tr>
<td></td>
<td>don’t assume trust between elements</td>
</tr>
<tr>
<td>app stores</td>
<td>keep it application-neutral</td>
</tr>
<tr>
<td>FTTH, backhaul cost</td>
<td>re-use backhaul where you can find it</td>
</tr>
</tbody>
</table>

*Premature optimization is the root of all evil* (Knuth 1974)
Lesson: sensor networks may be (tiny) niche

- Most IoT systems will be near power since they’ll interact with energy-based systems (lights, motors, vehicles)
- Most IoT systems will not be running TinyOS (or similar)
- Protocol processing overhead is unlikely to matter
- Low message volume → cryptography overhead is unlikely to matter

In particular, according to the indexes, a Raspberry Pi is about seven times as fast as a baseline SPARCstation 20 model 61 — and has substantially more RAM and storage, too. And the Raspberry Pi 2 is sixteen times as fast at single-threaded tasks, and on tasks where all cores can be put to use it’s forty one times faster.

$35.00

- A 900MHz quad-core ARM Cortex-A7
- 1 GB RAM

http://eschatologist.net/blog/?p=266
What is the best generic (simple) architecture?

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MQ135 Air Pollution sensor

SENML?

cloud, fog, ...

SQL (via HTTP RESTful API)

Streaming (JSON web stream ... RTP)

event notification

mediate access

user-delivered code

14 sensors!
How should we name things?

- network interface
- device (independent of network)
- domain name? → portability? phone number?
- device by function & location

“ceiling lamp in kitchen” (used in programs)

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Phone numbers for machines?

212 555 1212  < 2010

500 123 4567
(and geographic numbers)

500 123 4567
533, 544

< 2010

< 2010

5XX code a year...
(8M numbers)

12% of adults

254 mio.

5 mio.

311,000

64 mio.

44.9 mio.

10 billion +1 #’s available


2/2/2016

see Tom McGarry, Neustar
How should we secure things?

Old model

New model

"I want to join!"

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SECE (Sense Everything, Control Everything)
Conclusion

• Design for simplicity and generality, not performance
• Design for surprises
• Design for developers – what do they need and want?
• Design for L2 evolution and co-existence