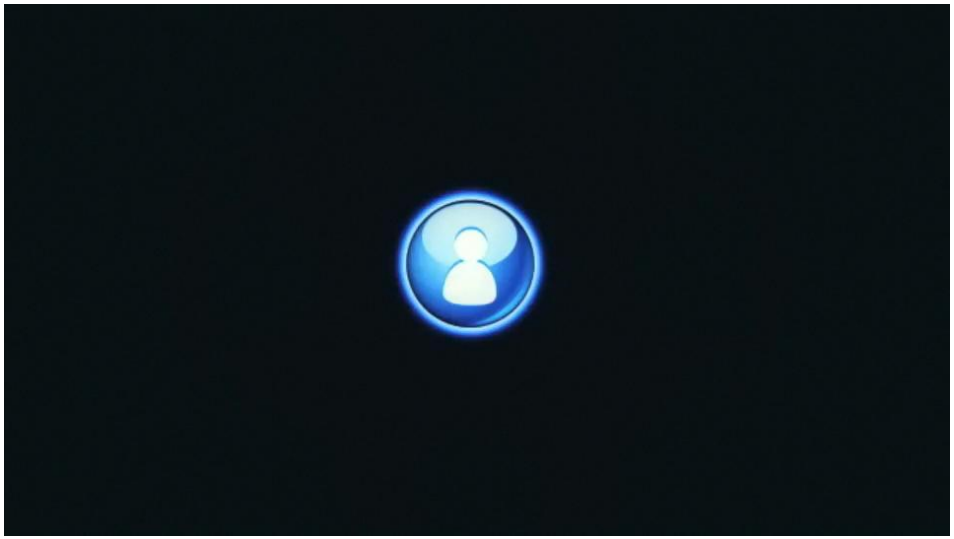
The Swarm at the Edge of the Cloud

Edward A. Lee, Director

Jan Rabaey, Associate Director

UC Berkeley



BEARS Conference

EECS Department, UC Berkeley

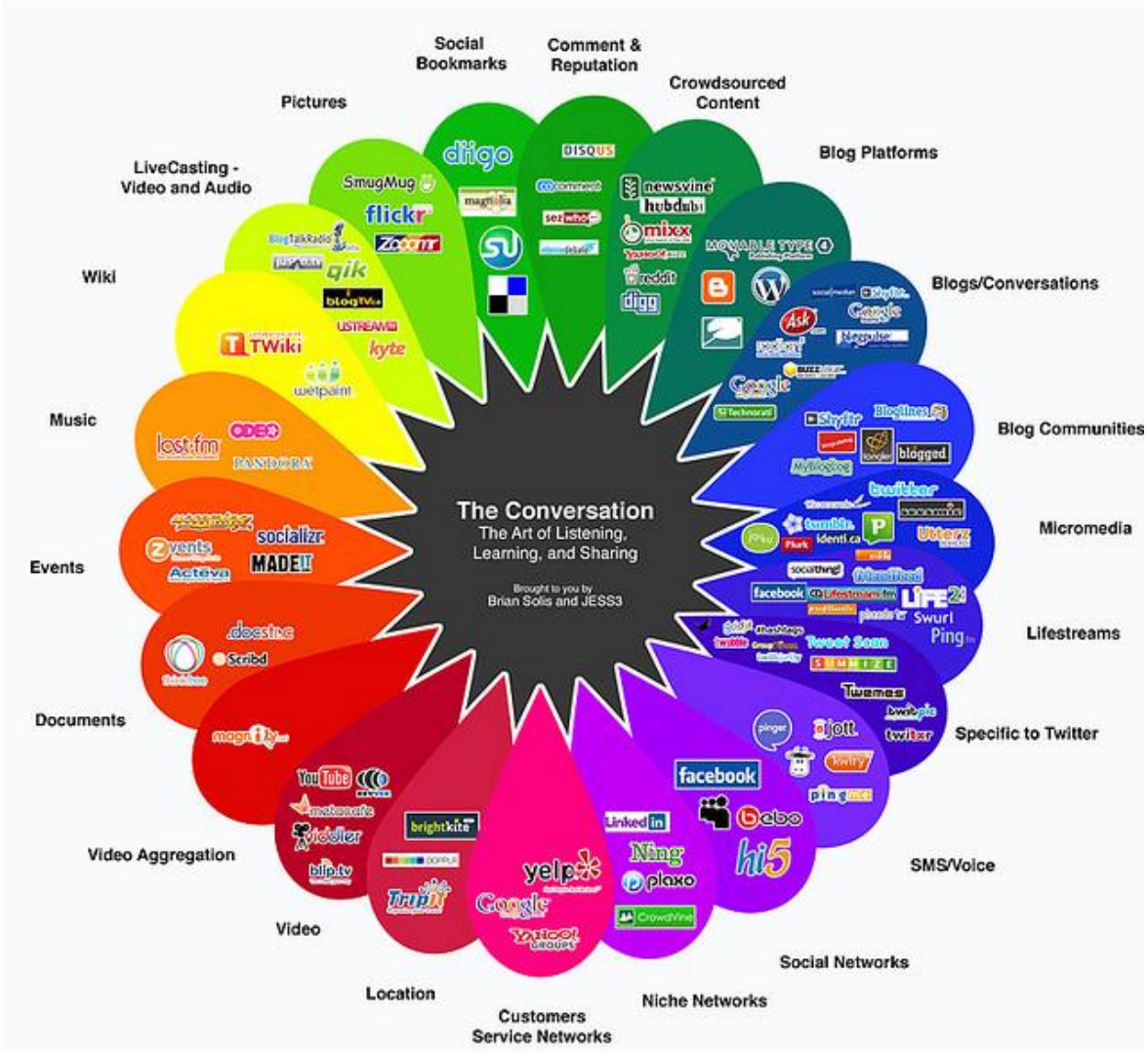
February 14, 2013

Sponsored by the TerraSwarm Research Center, one of six centers administered by the STARnet phase of the Focus Center Research Program (FCRP) a Semiconductor Research Corporation program sponsored by MARCO and DARPA.

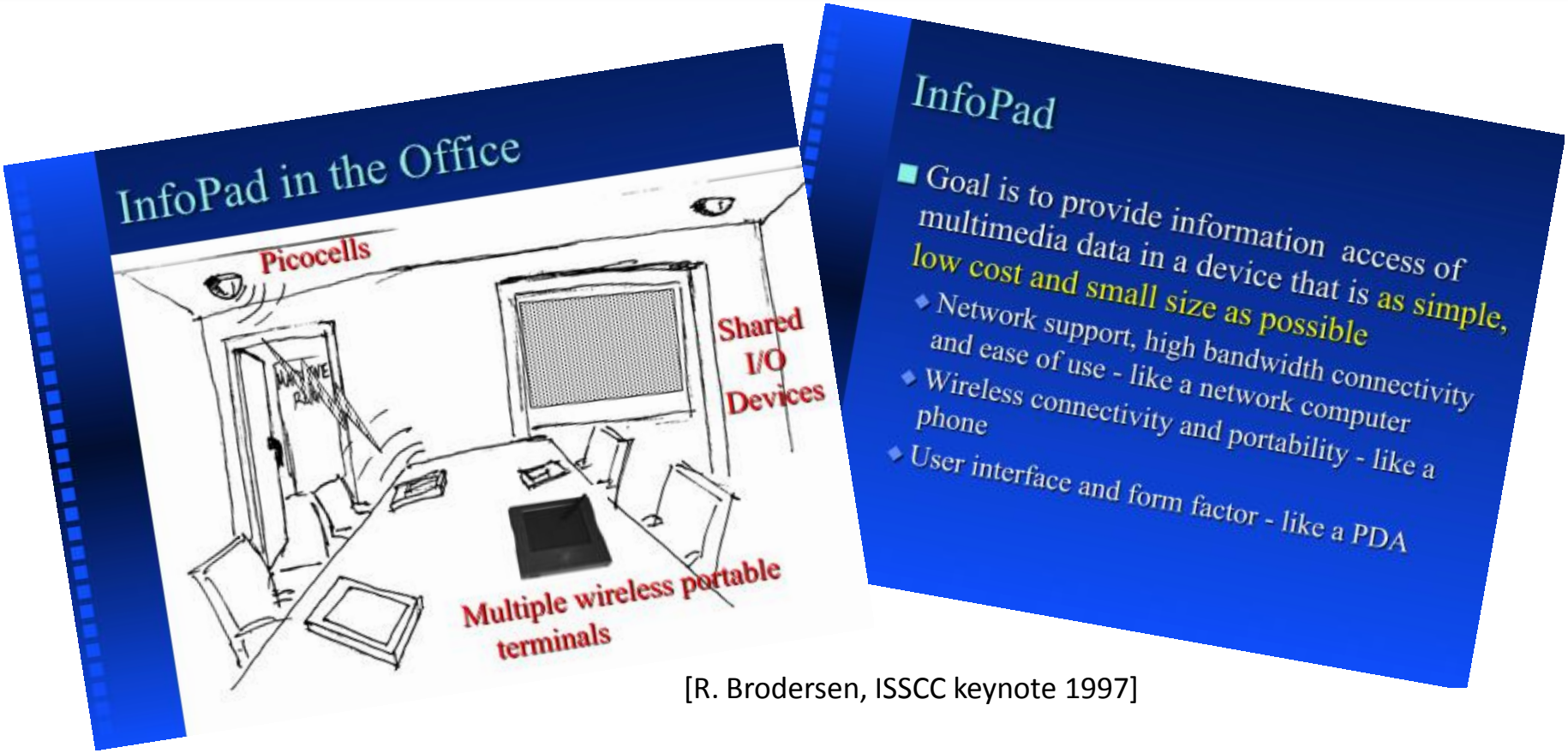
The Backdrop: Information Technology

The Cloud

Value from Data Aggregation



Today's Big Thing: The 20 year overnight revolution of wireless handheld devices



[R. Brodersen, ISSCC keynote 1997]

The Birth of the Wireless Tablet

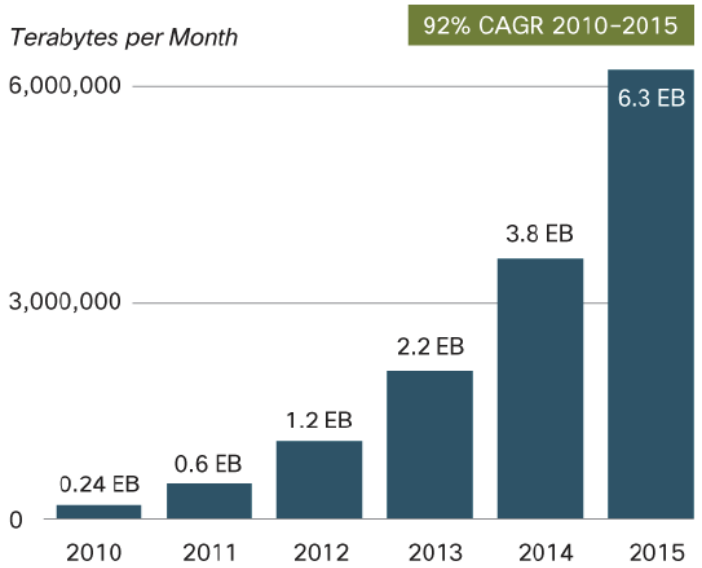
The UCB Infopad Project (1992-1996)

The IT Platform of Today: Mobiles at the Edge of the Cloud

[J. Rabaey, ASPDAC'08]

Mobile data growth

[Source: Cisco VNI Mobile, 2011]



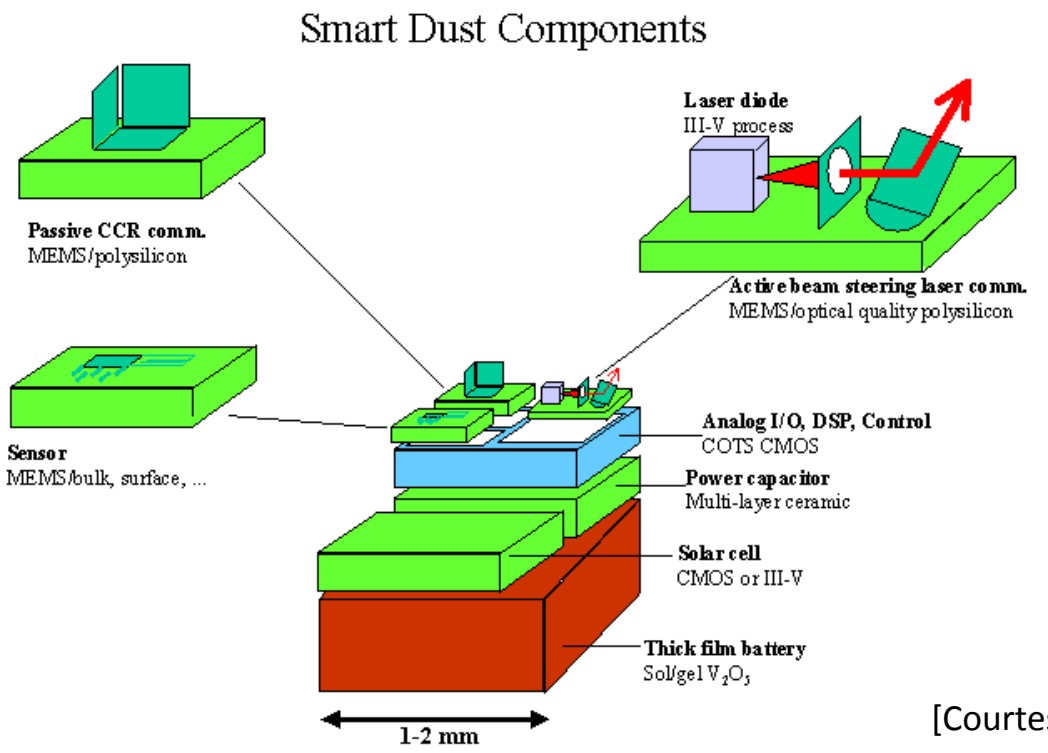
Mobile traffic grew 2.6x in 2010 (nearly tripling for 3rd year)

Driven by Tablets

The Swarm at the Edge of the Cloud

[J. Rabaey, ASPDAC'08]

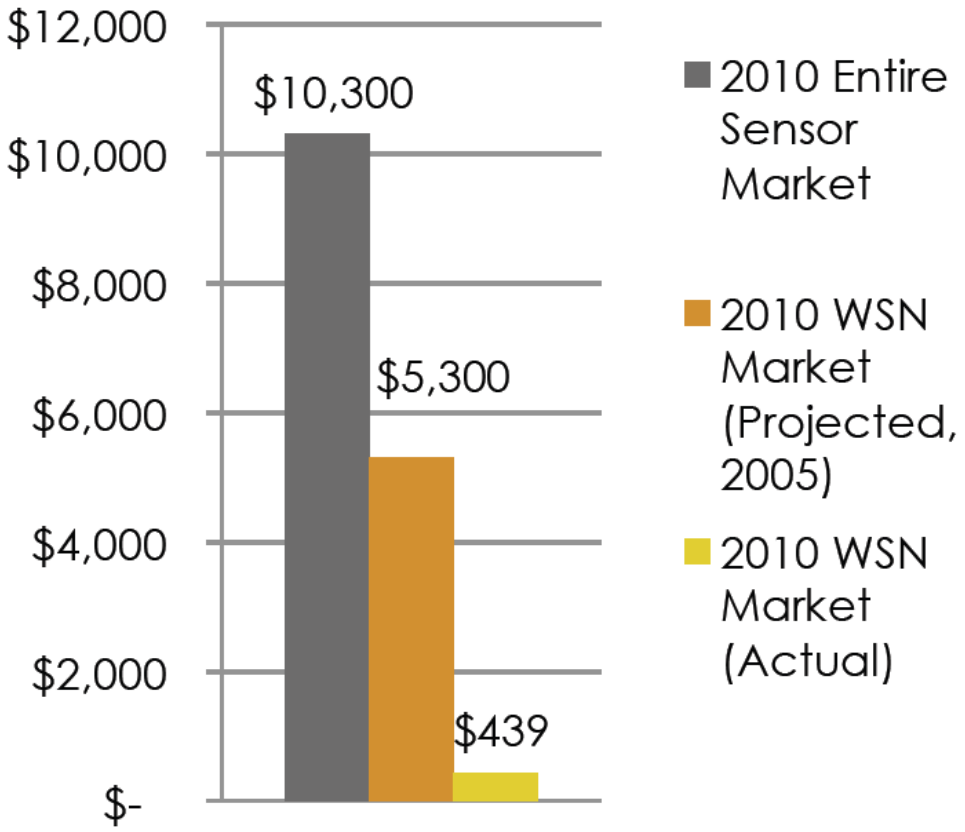
1995 Question: What happens if sensors become tiny, wireless, and self-contained?



[Courtesy: K. Pister, UC Berkeley]

… Wireless Sensor Networks

2010 Outcome: The Unfulfilled Promise of Wireless Sensor Nets



Source: On World

What slowed them down?

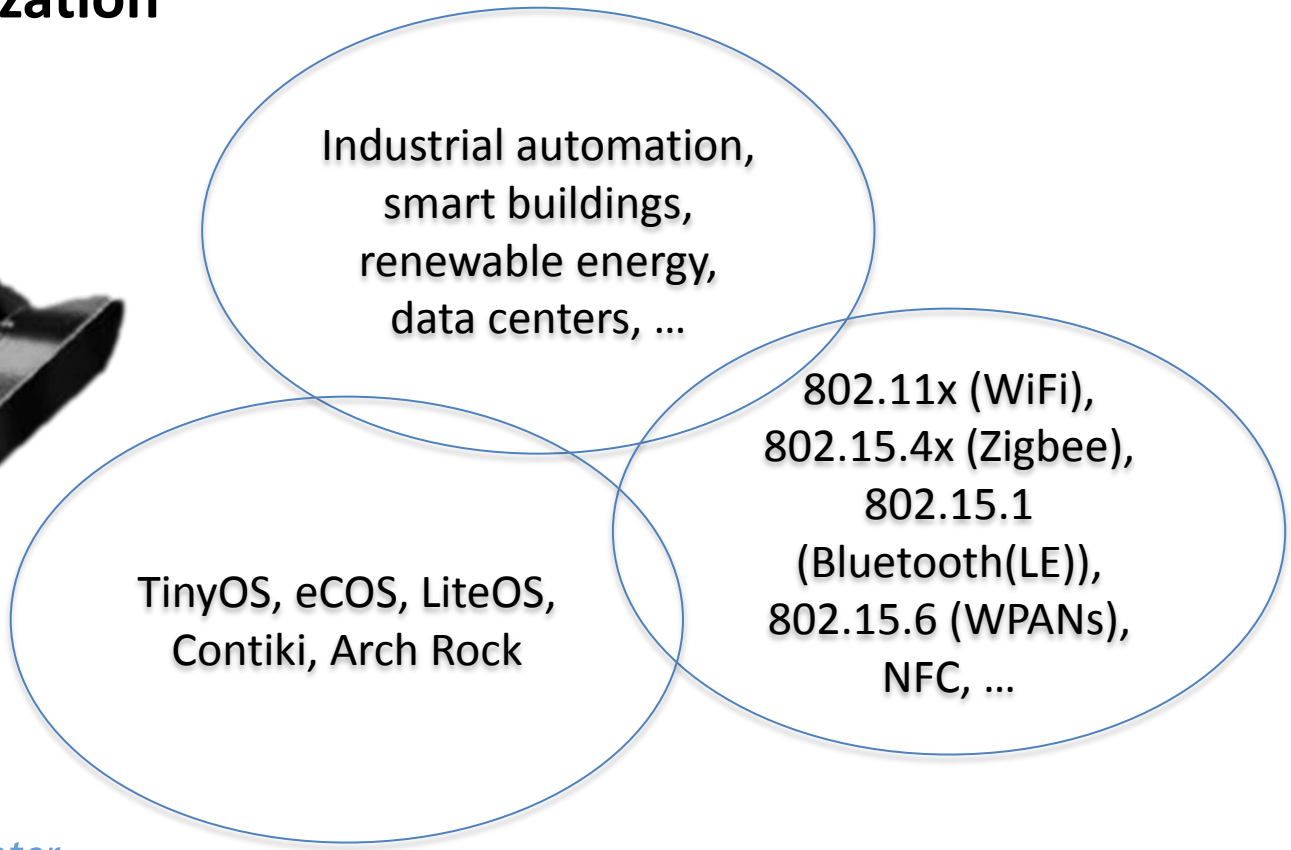
(Source: On World)

- Cost savings not yet disruptive
- Reliability
- Energy (battery life)
- Ease of use

[J. Rabaey, VLSI keynote 2011]

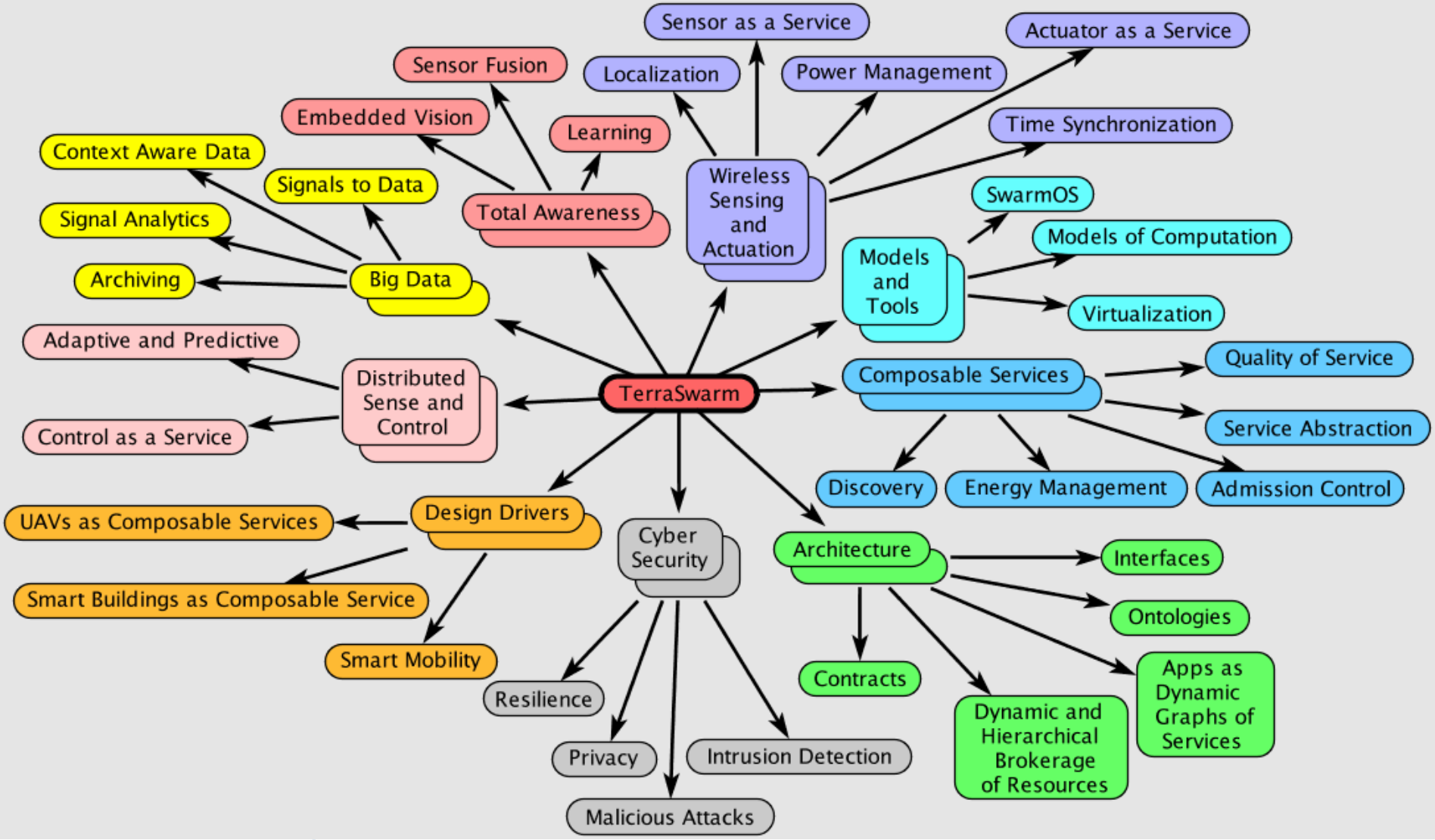
Wireless Sensor Nets
What REALLY slows them down:
NO Economy of Scale

Stovepipes, Fragmentation, Non-interoperability, Lack of Virtualization

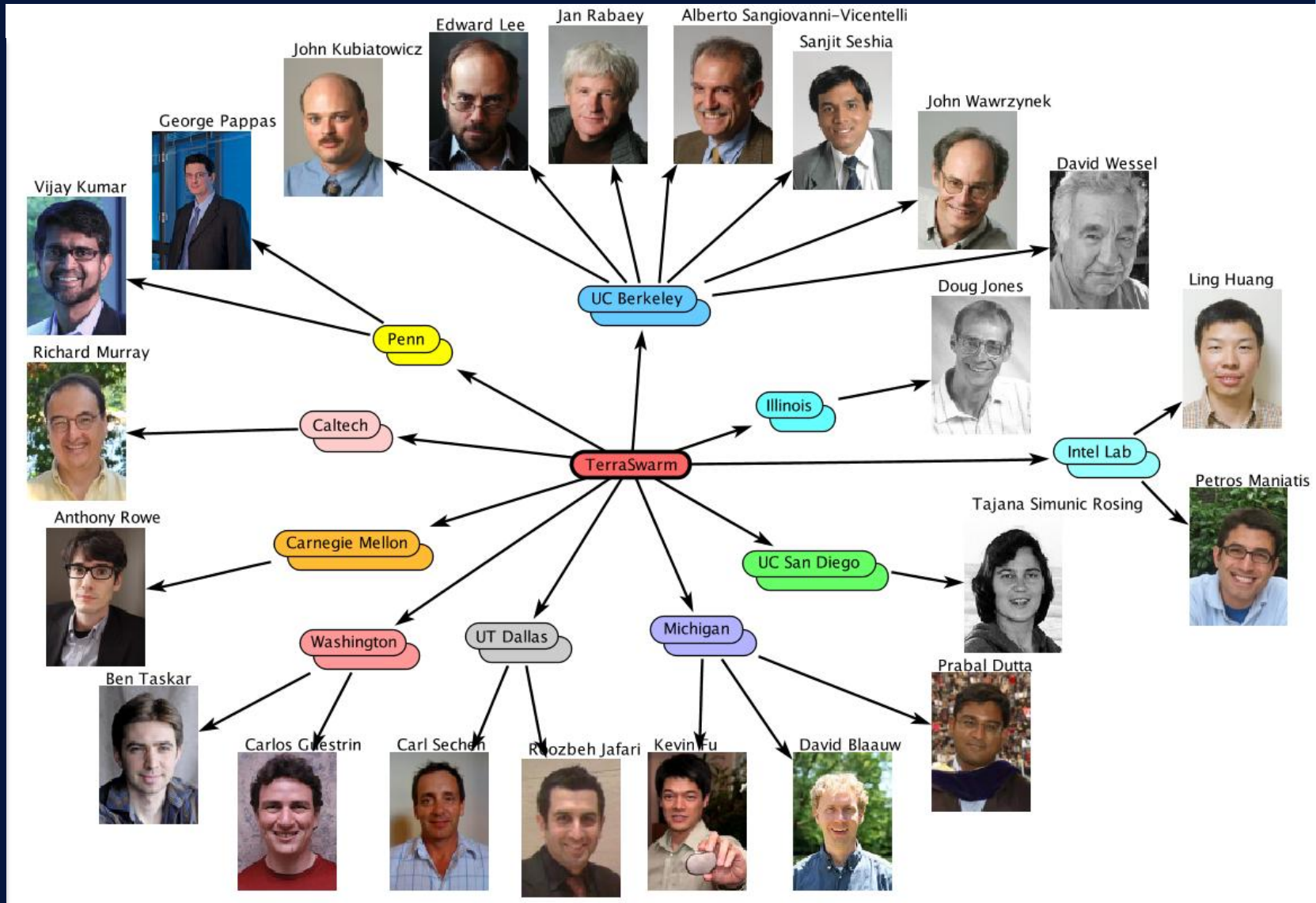


[J. Rabaey, VLSI keynote 2011]

The TerraSwarm Problem Space



The Team


Edward Lee
Jan Rabaey
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George Pappas
John Wawrzynek
David Wessel
Vijay Kumar
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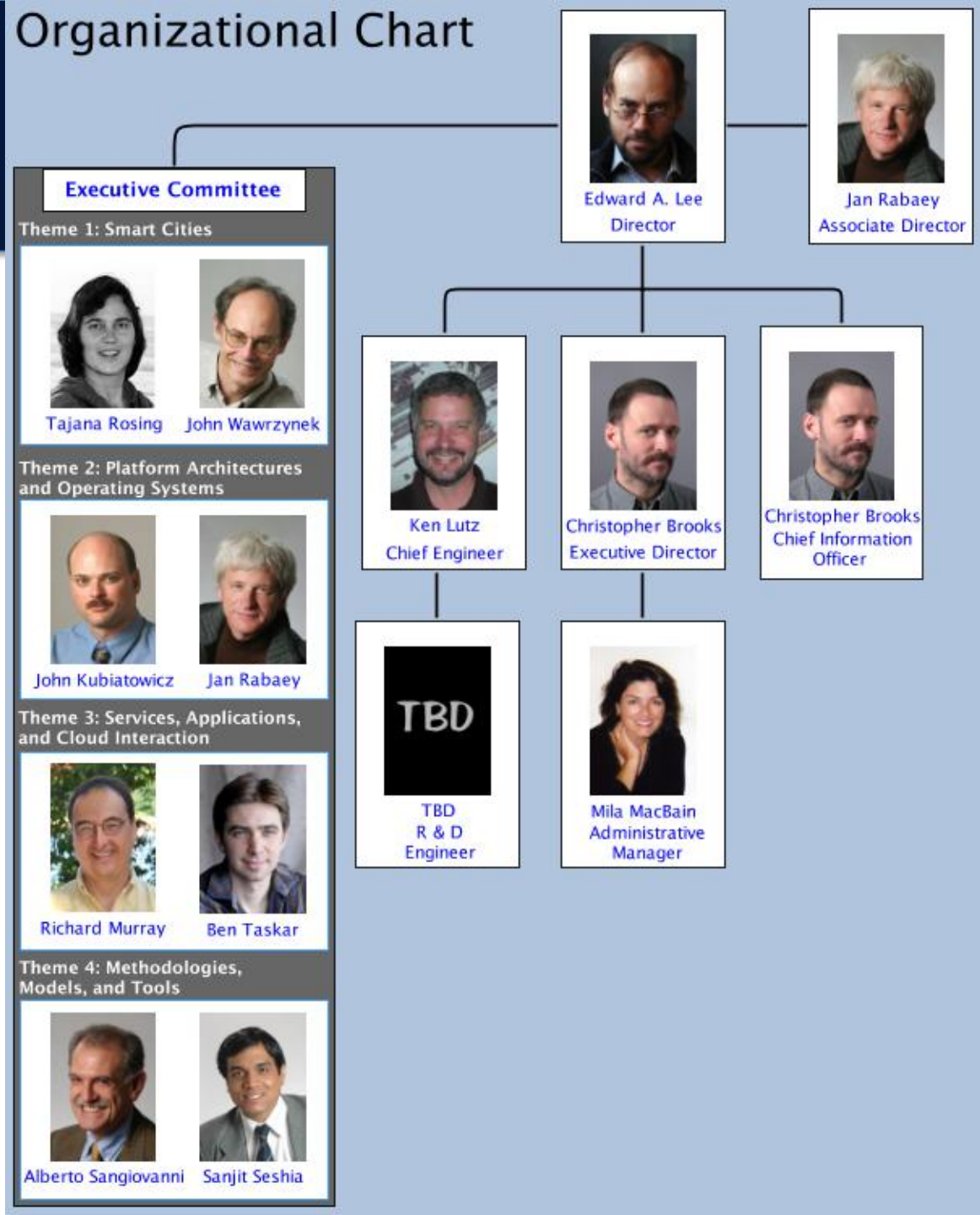
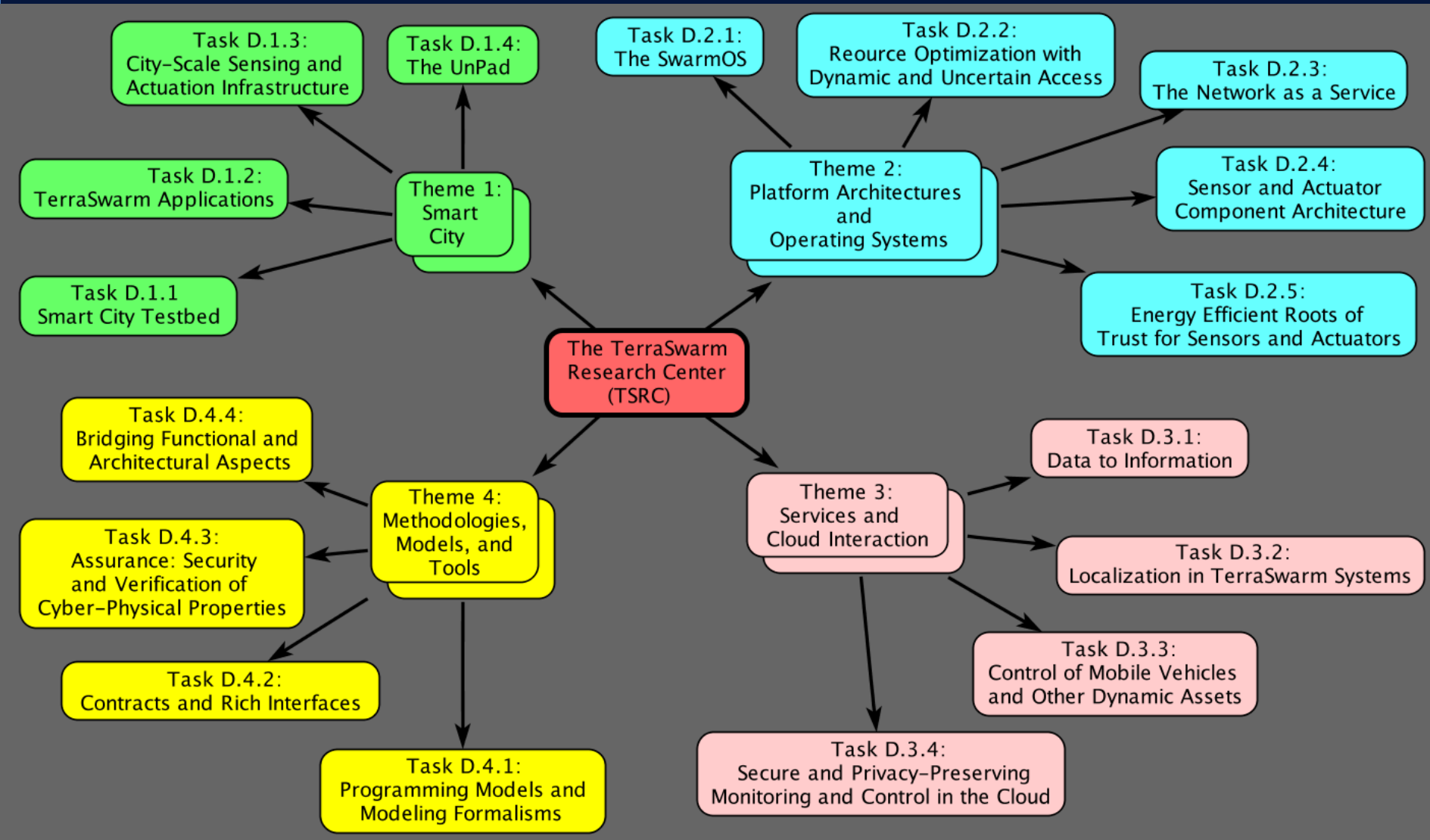
TerraSwarm
Intel Lab
Petros Maniatis
Tajana Simunic Rosing
Anthony Rowe
Carnegie Mellon
UC San Diego
Washington
UT Dallas
Michigan
Prabal Dutta
Ben Taskar
Carlos Guestrin
Carl Sechen
Roozbeh Jafari
Kevin Fu
David Blaauw

Organization

- Director
- Associate director
- Executive director
- Executive committee
- Chief engineer
- Chief info. Officer
- R&D engineer
- Admin. manager
- Executive advisory board



Center Themes



Theme 1: A Tale of Two Cities

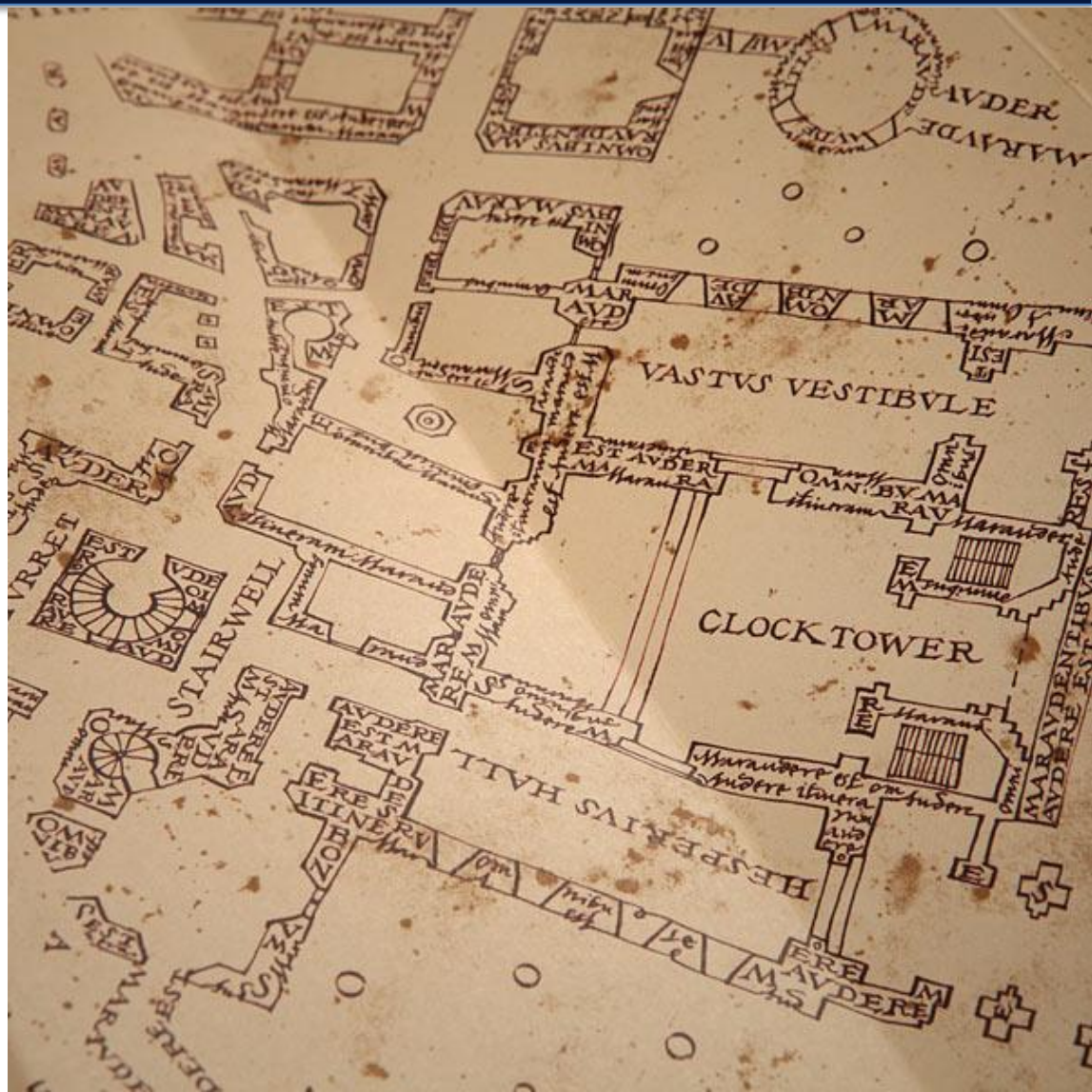
Atlantic City, October 28, 2012

Atlantic City, October 30, 2012

Sample Application: The Marauder's Map

"I do solemnly swear that I am up to no good."

Incantation that activates the Marauder's Map in Harry Potter.



Security

Open architectures with dynamically recruitable sensors open enormous security and privacy concerns. But recent innovations show that data aggregation and networking can be used to *enhance* security and privacy.

The risks of Swarms

E.g., Differential privacy [Dwork et al., 2006] provides a framework for removing side-channel information that can be derived by cross-correlating data sets.

In another example, tighter coupling of time bases in distributed systems (time synchronization) provides a framework for detecting and countering denial of service attacks.

Safety in Numbers

Large numbers can also improve robustness and reliability

Humans

- **10-15% of terrestrial animal biomass**
- **10^9 Neurons/"node"**

Ants

- **10-15% of terrestrial animal biomass**
- **10^5 Neurons/"node"**

[D. Petrovic, UCB – Atheros]

Easier to make ants than humans

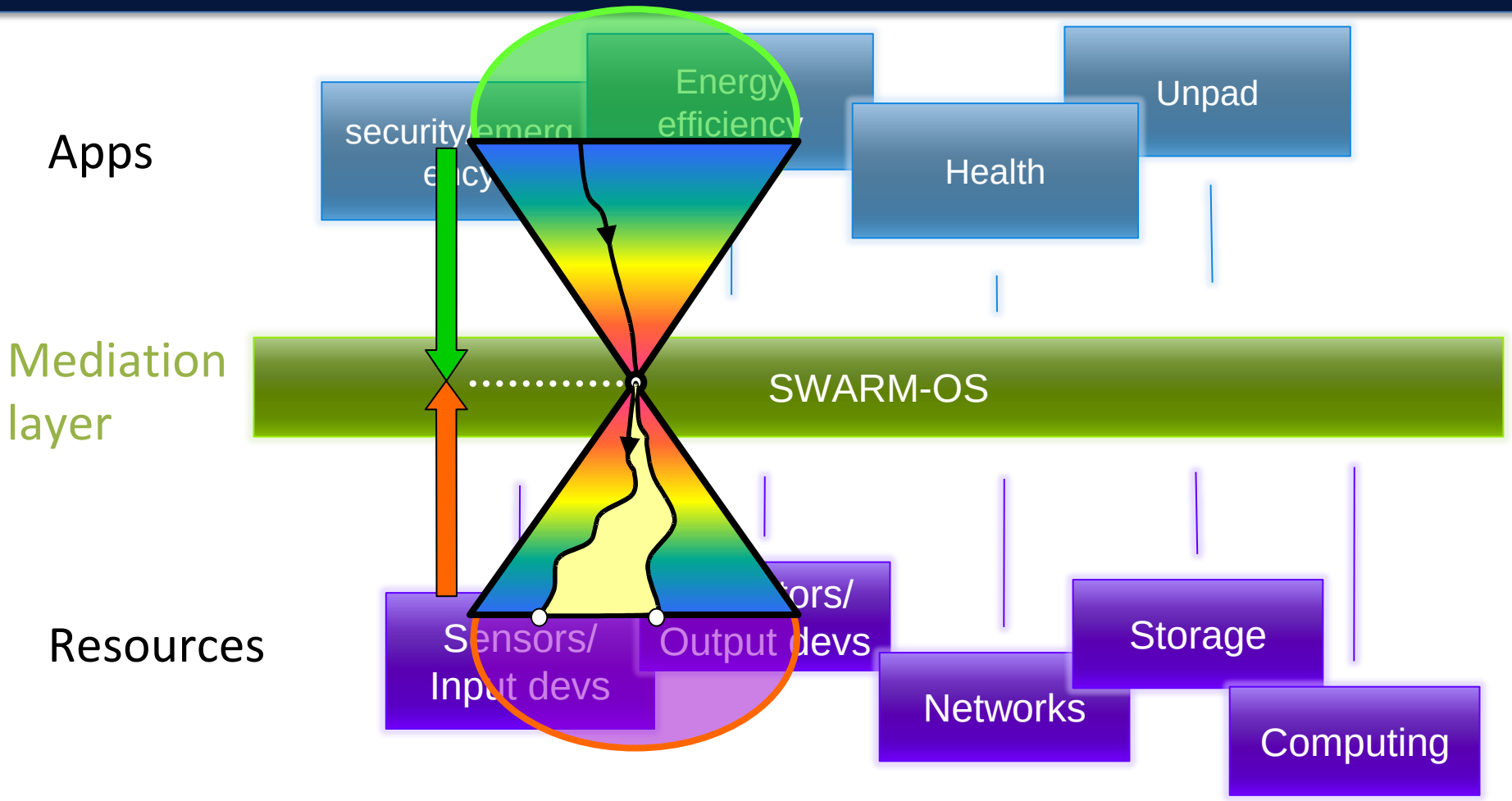
"Small, simple, swarm"

[J. Rabaey, VLSI '11]

Bridging the Cyber with the Physical

- Computation is discrete
- The physical world is not
- Naïve bridges between the two fall short

The Swarm as a Platform



Presenting a uniform API to Apps Developers (similar to trends in the Cloud)

[J. Rabaey, VLSI '11]

Questions?