Proactive Computing:
RFID & Sensor Networks

RFID and The Internet of Things

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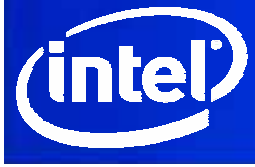


Agenda

- **Set the Stage:**
  Intel's Strategies for Proactive Computing
- **Business Driven RFID & Sensor Network Strategies**
  - **RFID "End-to-End" inside Intel**
- **What's on the Horizon**
  - **Scale the Proactive Computing Ecosystem**

Proactive Computing Technologies:
Vision & Definitions

Proactive Computing Vision

Today
Computers are interactive

We are always waiting for them or vice-versa

Tomorrow
Computers will be proactive

They will anticipate our needs and act on our behalf

Computation so ubiquitous and convenient that people reach for it as reflexively as a light switch…

Today		Tomorrow
Human-centered	→	Human-supervised
Deterministic	→	Stochastic
Managed	→	Autonomous

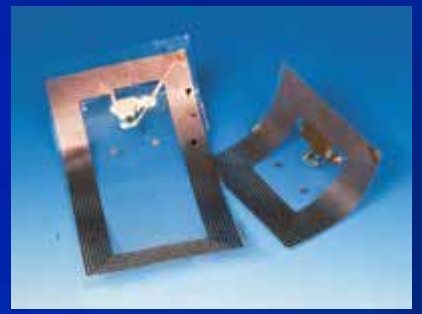
Proactive Computing:

Def. **ubiquitous computing systems acting in anticipation of future problems, needs, or changes of the user**

- **To be proactive a computer system must understand the user's context and how it changes over time**
  - ***Who*** **the user is, who they are with,**
  - ***Where*** **they are**
  - **When they are**
  - ***What*** **they are doing**
- **To be autonomous a computer must be able to take care of itself (i.e., Self-Manageability, Self-Diagnosis & Repair)**

What are Proactive Computing Technologies?

- **Identifying technologies**
  - **RFID** - Radio Frequency Identification
    - Capture, retain, transmit data about an object
  - **Auto-ID** - Automatic Identification
    - Identify an object via data standards & linkages
  - **Provide:** Identification, State, Location



- **Sense & Respond technologies**
  - Combination of tags & sensors in an environment based on need
  - Sense the environment
  - Make inferences - about location, context, etc.
  - Participate in information aggregation, statistical computing and dissemination activities
  - Give appropriate responses, take appropriate actions
  - Proactively communicate with other objects, people, computing systems

RFID is an early Vehicle for readying these future Proactive Computing Ecosystems.

A Sampling: Intel RFID PoCs

Intel's Business Inside

- World-class semiconductor manufacturing
- Global logistics and factory operations
- Extended and interconnected supply and demand network
- Evolving markets and platforms
- New business problems emerging
  - can't be solved with conventional means or technology
- Not "mandate" driven

The Goal:
Product and Process transformation through Proactive Computing capabilities

Why End-to-End?

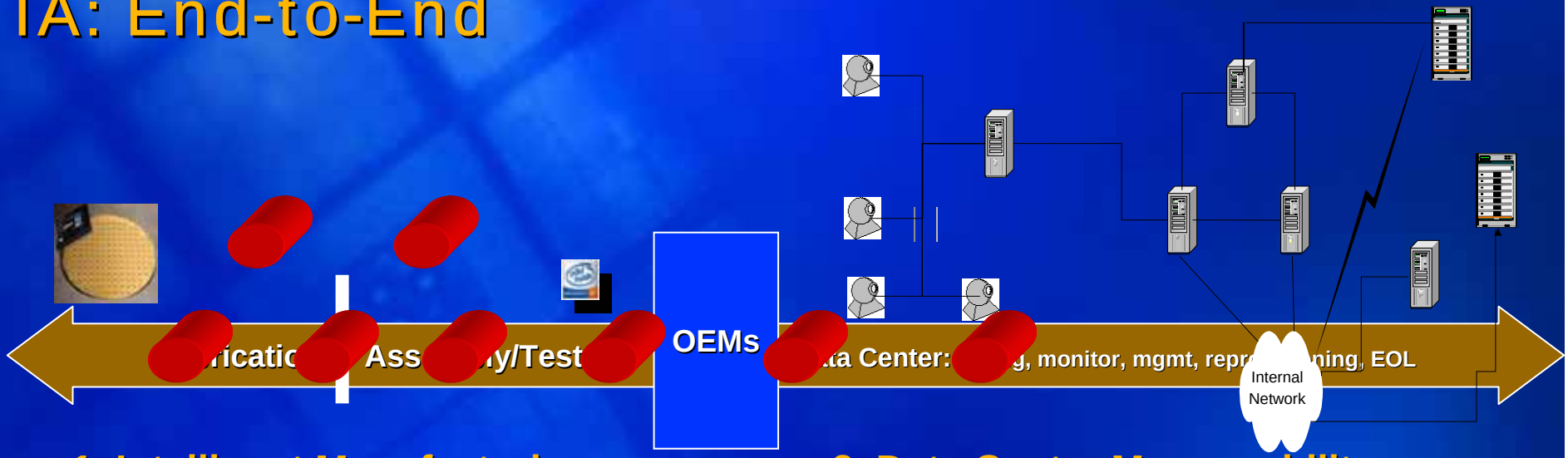
RFID value increases with *persistence.*

Assert that two END-TO-END expansions create much greater value and benefits:

- **BY NETWORK:**
  when RFID technologies are deployed throughout the supply network, so that smart objects can be traced throughout the network.
- **BY TIME:**
  when RFID technologies deployed on a product can manage that product throughout its product life cycle, from product generation all the way to product return and disposal.

The END-TO-END impacts can result in structurally different ways to manage business and use information technology.

The "Smart Machine" Lifecycle
IA: End-to-End



1. Intelligent Manufacturing
Supply Chain Manageability

2. Data Center Manageability
Integrated Infrastructure Autonomy

Usage potential:

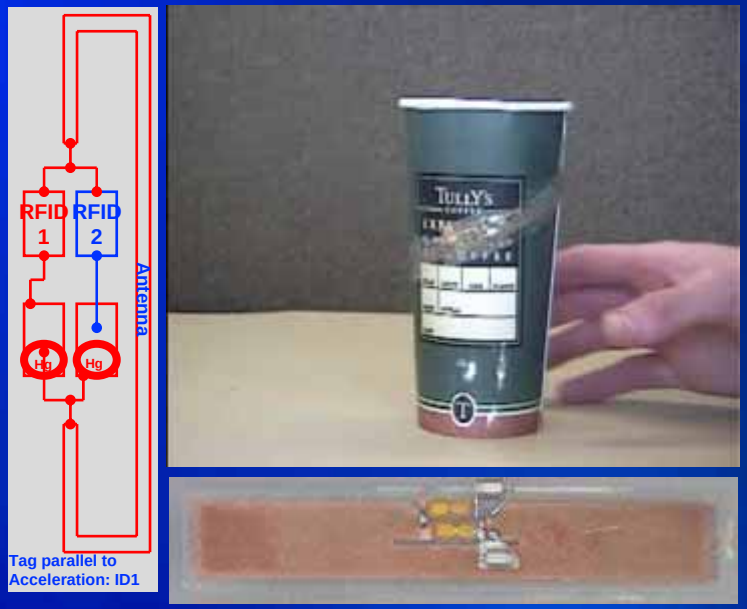
Traceability, tracking, asset/inventory management, and self-diagnosing / self-correcting processing.

AND pedigree/quality validation, verification, process control, excursion management, security, brand protection, recording device, training, activity inference, customer service

RFID Artifacts – Paradigms of Use

Infrared FindIT Flashlight
(MIT Media Lab)

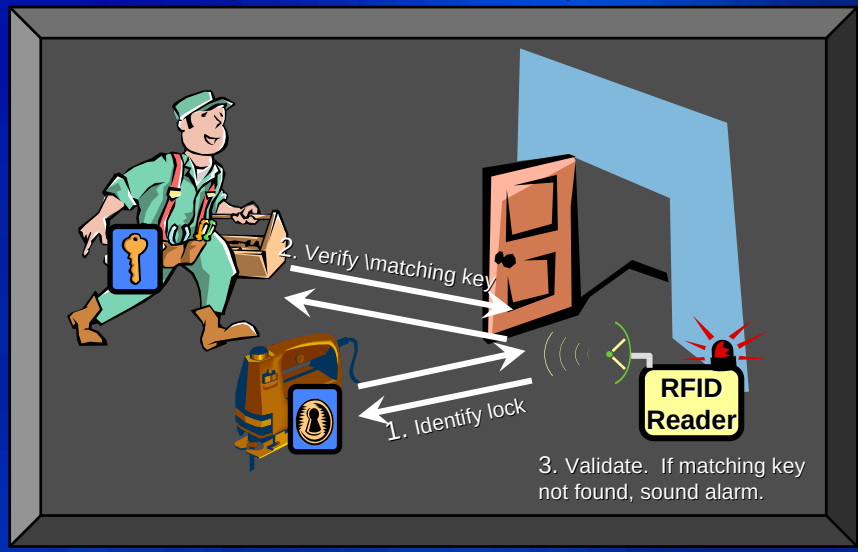
Fig. 1. Tag (with DIP-8 PIC12C509 shown here) and flashlight transmitter-interrogator



a-WISP wireless, battery-free 1-bit accelerometer
(Intel Research Seattle Lab)

Integrated Reader & Mote-based iGlove
(Intel Research Seattle Lab)

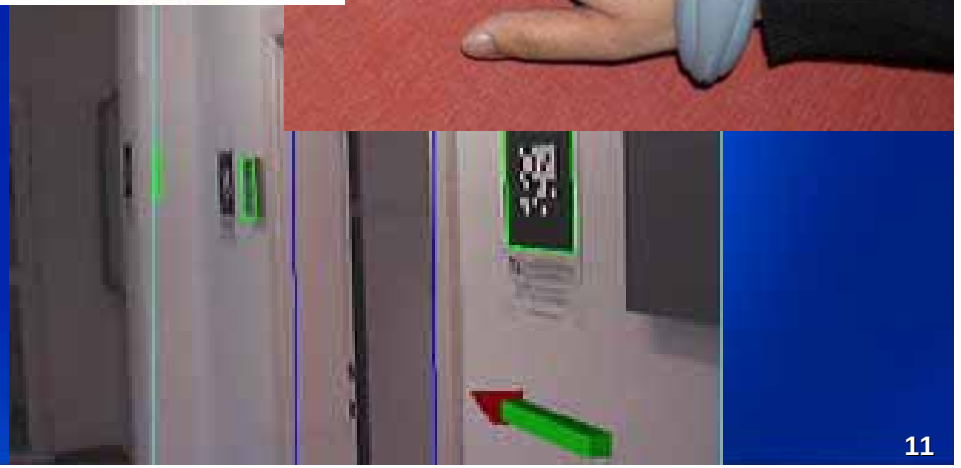
Multi-sensor board
(Intel Research Seattle Lab)



Anonymous Lock & Key (Sensor Network Research)

iBracelet:
Optimized Performance

- Bracelet : MOTE and modified Skyetek RFID reader with custom printed antenna
- Tags embedded in the environment
- Model construction based on explicit knowledge
- PO-MDP inferencing
- BKM capture, proactive apps, augmented reality enabler



RFID End-to-End

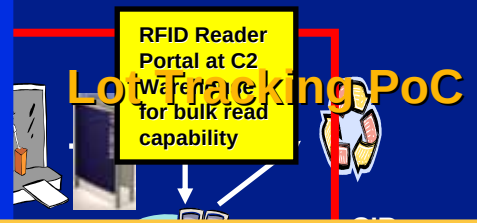
BUSINESS VALUE:
Locate specific WIP material in the factory – productivity impact
TECHNOLOGY VALUE:
Battery-powered RFID tags + RF coverage in complex factory setting


ATD Tag


Tag on cart


IHS & Epoxy 'cart farms'


Blinking tag



Lot Tracking PoC

BUSINESS VALUE:
End-to-end Visibility For High Volume Intel Products Across Enterprises

TECHNOLOGY VALUE:
Create Distributed Information Architecture For Our Smart Objects

Anti-Mixing PoC

BUSIN
Ensure
for automated Die-Side Attach –
product quality & customer impact

TECHNOLOGY VALUE:
RFID Artifacts (iGlove, multi-antenna arrays) + NG Equipment design

Supply Chain PoC

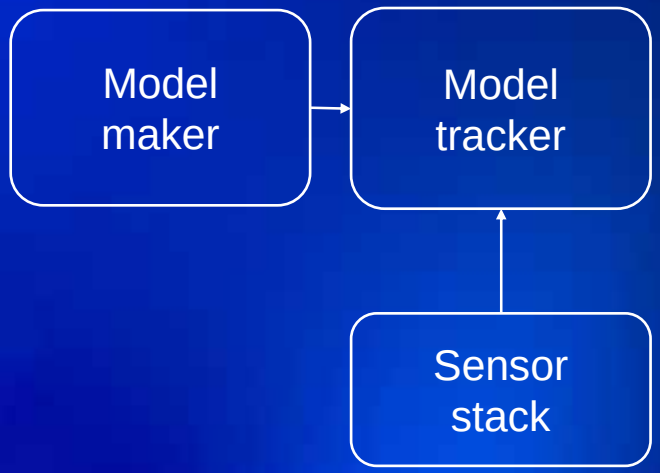
Activity Inference:

'understanding physical activities and interactions'
– Intel Research Seattle.

- What people use* is a key way to characterize many activities

Anticipating by inference – key issues

1. **Sensing - reporting meaningful features across many activities and scenarios**
2. **Representation: tractable model accommodating variations and uncertainties in activities**
3. **Creation: simplifying the process of creating and maintaining usable models**

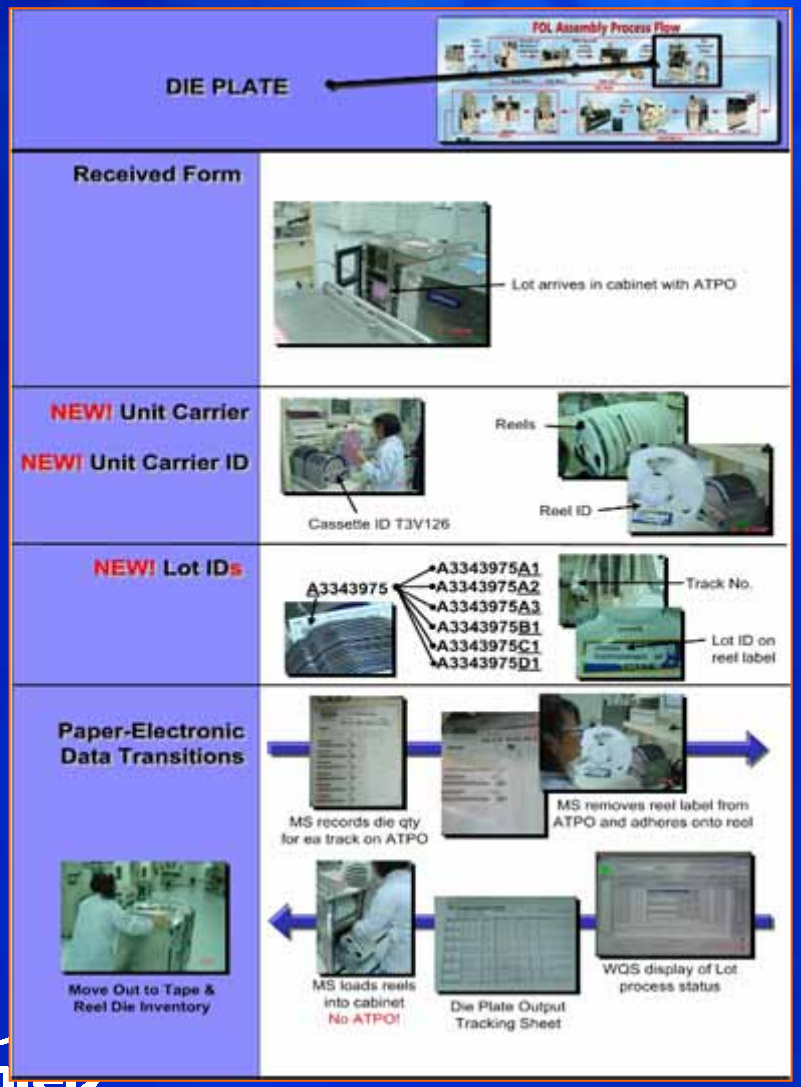


What's Next for RFID - 2006

- **Meeting the Physical World:**
  The Internet of Things
- **Get "Proactive" by Design**
- **Is the Data where it Matters?**
- **Make it SCALE**

Logical to Physical Interconnection

What are the implications of the physical world meeting the logical world?



RFID connects the physical world with logical systems creating new links:

Who am I?
What am I?
Who am I with?
Where am I?
When am I?

Does a physical vs a symbolic representation change localized processes?

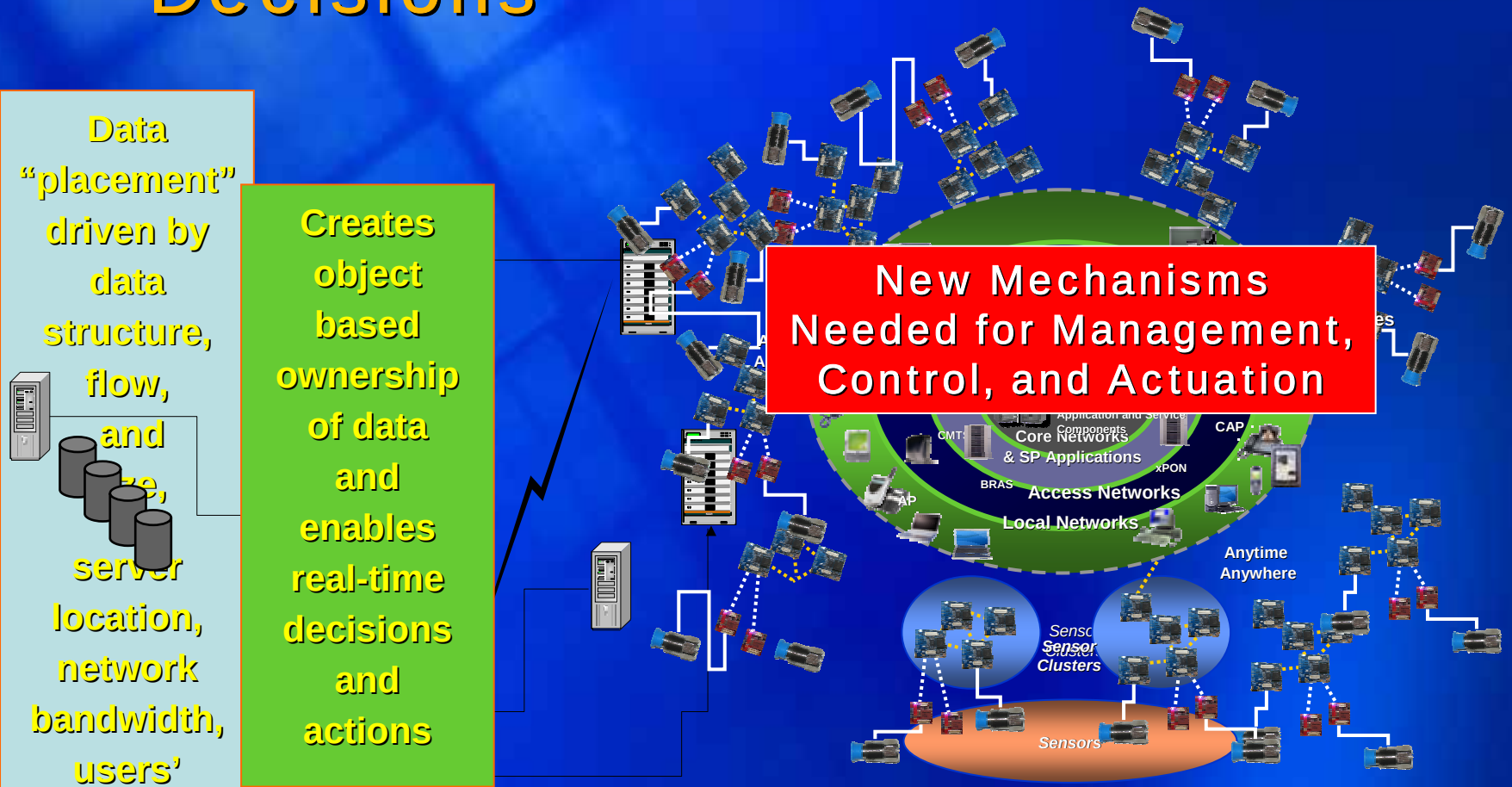
The physical world is not bound or controlled in the same way; does this enable more business flexibility?

What new connections does RFID create between the physical and logical worlds and what impact will that have?

Distributed Data – Real-Time Decisions

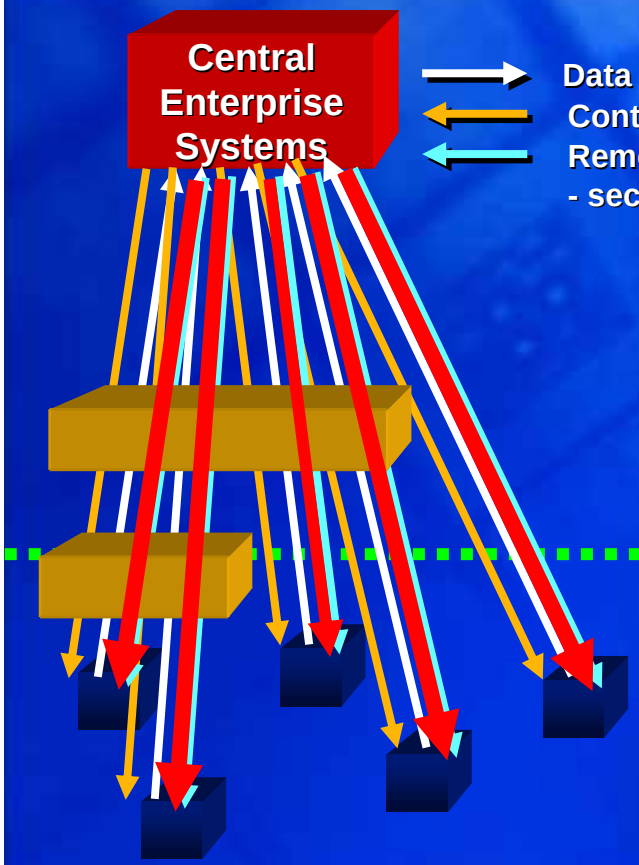
Data "placement" driven by data structure, flow, and [illegible] server location, network bandwidth, users' needs, latency…

Creates object based ownership of data and enables real-time decisions and actions



1. **Data can be represented** at an atomic level in terms of the object.
2. **Data can be shared** based on mutual self-interest and perceived value.
3. **Data can be aggregated** across many objects to provide insight into a collective state.
4. **Different integrated data views** available, regardless of perspective or location in the extended enterprise.
5. **"Data in Motion"** requires: physical transactions + context + meaning

Network Implications: The Data

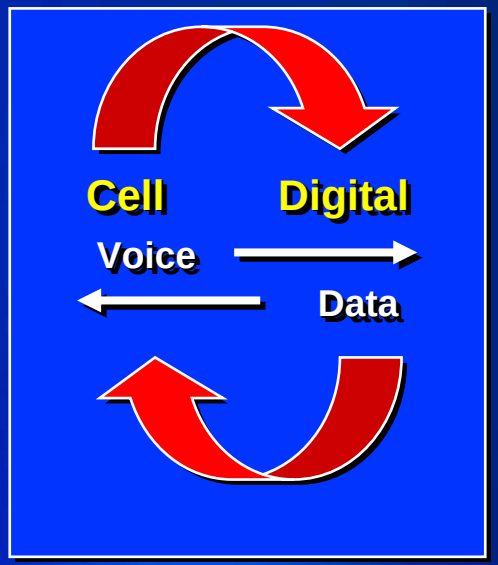


Data to enterprise: Summary & Meaning
Context: Global Data Sync
Remote Management
- security, power, config, dynamic provisioning

Access Network
- wired
- wireless

Ad Hoc Networks
- RF network
- Mesh network

The "network" switch



Centralized enterprise apps moving to app services on an edge device

AN ANALOGY:
- "Cell network" for things talking to each other…
  - …and I remember what I was saying and call you back
  - Real-time high throughput data
  - Mobile connectivity
  - Permutations of use models
  - Self-manageability & guaranteed delivery

What does this mean ?

Compute-Communication Infrastructure

- Data explosion
- H
- P
- P

The emergence of proactive computing technologies triggers

a significant transformation in the extended data, application, and IT infrastructure architectures

This carries a range of implications :

- Contentious consumer issue
- Infer context to protect individual privacy

C model
ata
Adaptive mining model refinement and management

Summary

- Commercial RFID infrastructure is rapidly being built
- Sensor Networks are following RFID in deployments
- Deployments of RFID and Sensor Networks mark the beginning of proactive computing
- Networking the physical world leads to large streams of data AT THE EDGE
- It's time to ready the Ecosystem and make it Scale