A Network Service Provider's View of Ubiquitous Computing

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Answer to homework

- Ubiquitous computing and pervasive computing includes embedded devices, while nomadic computing does not.

Introduction

It's all about scale — ubiquitous computing means more endpoints and (much!) more data.

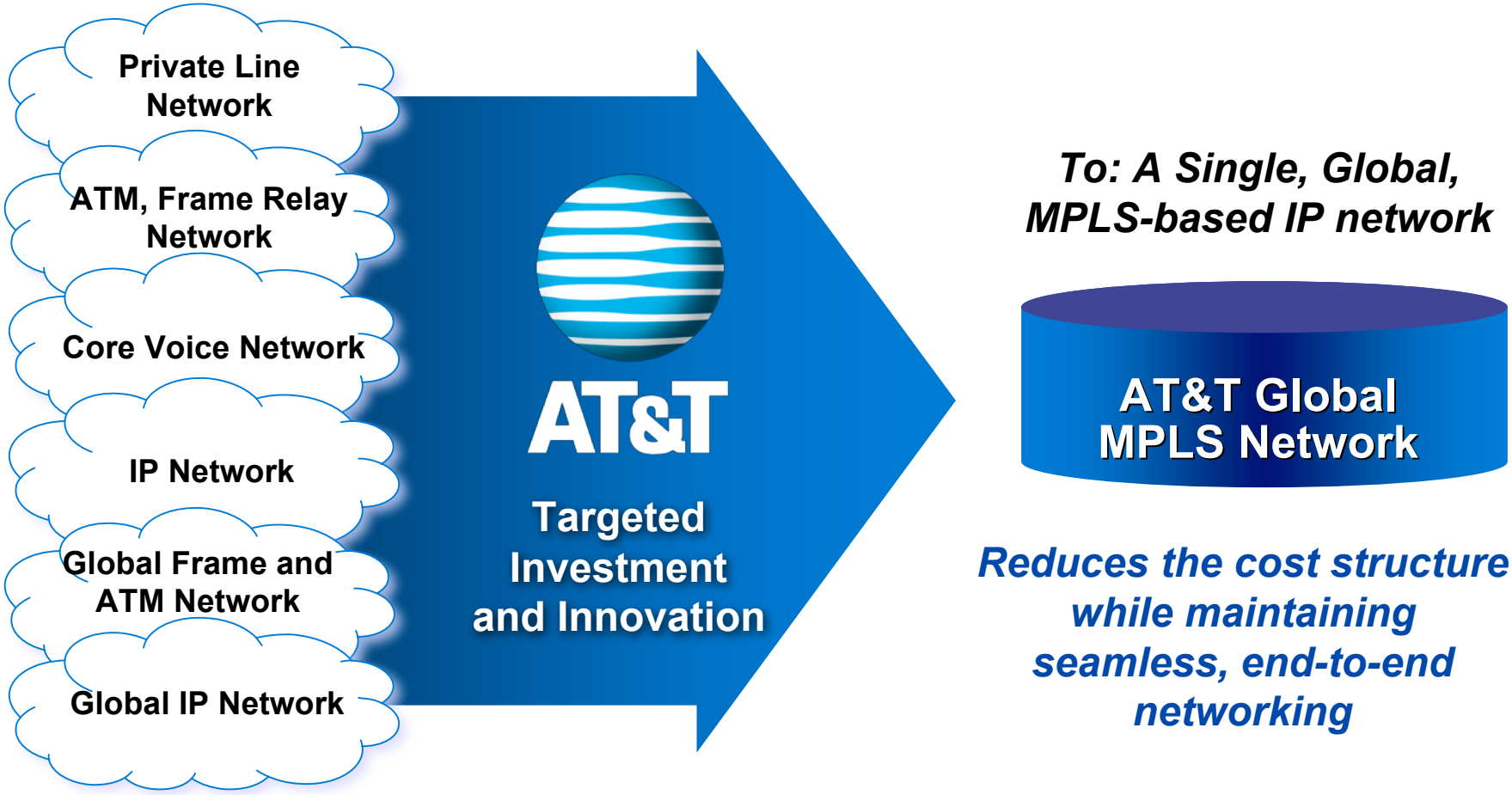
- **Talk Outline**
  - AT&T: Trends
  - Ubiquitous computing: Current business drivers.
  - Ubiquitous computing: Research in information and software systems.

AT&T: From Telephone Company to Network Service Provider

- **History**
  - 1876: Telephone invented by Alexander Graham Bell.
  - 1877: Bell Telephone Company founded; becomes parent of Bell System of local exchanges.
  - 1885: AT&T formed as subsidiary of Bell Telephone Company to build and operate long distance network.
  - 1899: AT&T becomes parent of Bell System.
  - 1925: Bell Telephone Laboratories established.
  - 1984: AT&T splits from 7 Regional Bell Operating Companies (RBOCs).
  - 1996: AT&T splits from NCR and Lucent (including Bell Labs); AT&T Labs formed.
  - 2005: SBC proposes to acquire AT&T.
- **Everything is now about IP, converged networks, and serving the enterprise space**
  - Operate largest IP backbone in the U.S.
  - 1000 MPLS switching nodes worldwide.
  - 76K miles of route fiber in the U.S.
  - First to provide coast-to-coast OC-192 (10 Gbits/sec).
  - Operate 22 IDCs
- **"The World's Networking Company"**

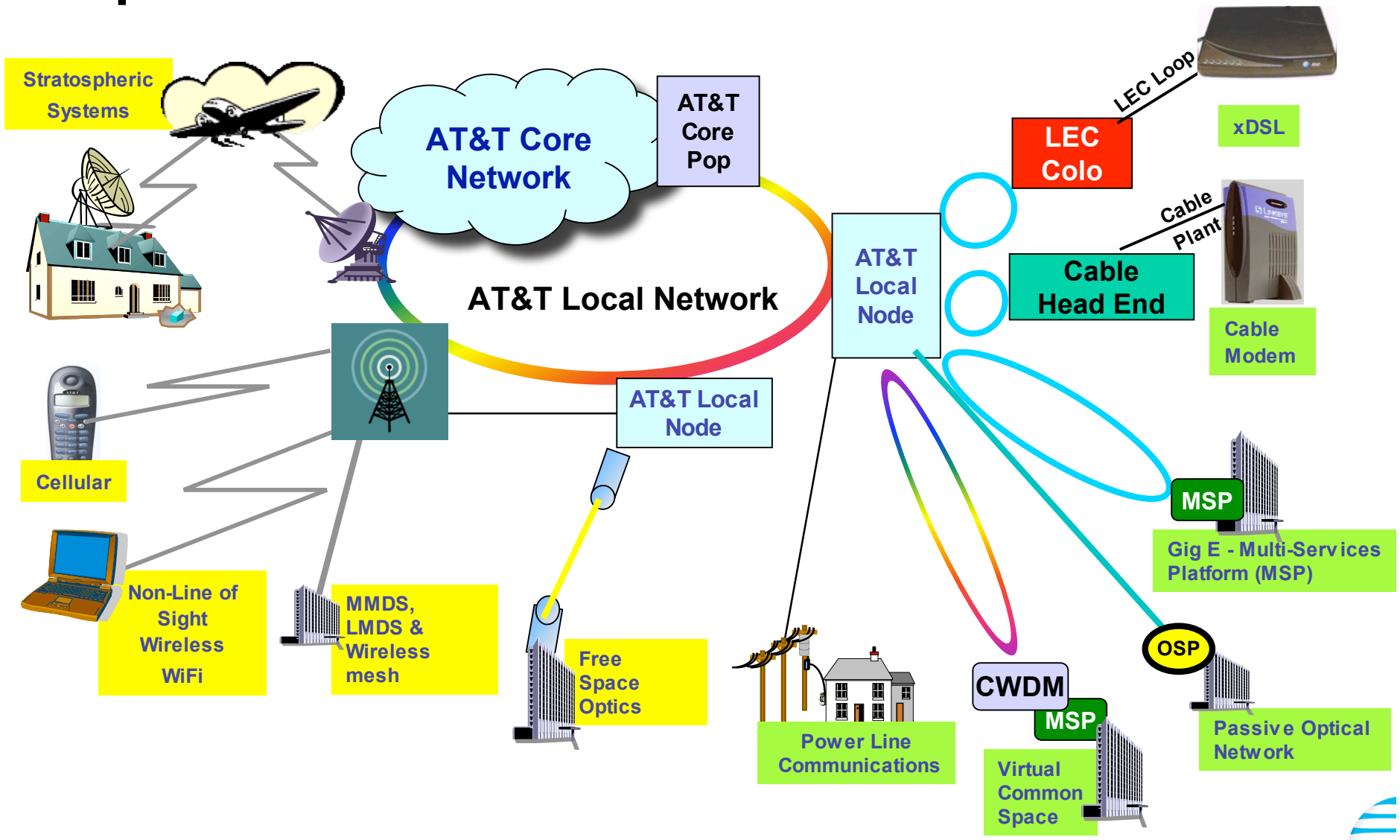
AT&T's Network Evolution

From: Multiple Legacy Networks



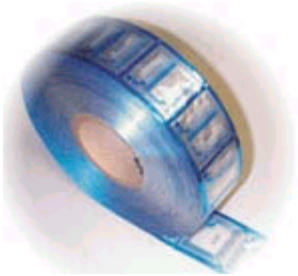
Reduces the cost structure while maintaining seamless, end-to-end networking

Heterogeneity: Access Technologies and Endpoints



Ubiquitous Computing: Current Business Driver is RFID

- RFID (Radio Frequency Identification) is being used and will become more prevalent in inventory and asset tracking systems
- Goal is to have RFID on every item in the supply chain
- EPC - Electronic Product Code
  - Electronic Product Code (ePC) is a new product numbering standard under development by the Uniform Code Council that can be used to detect, track, and control a variety of items using radio frequency identification (RFID) technology. The 96-bit ePC code links to an online database, providing a secure way of sharing product-specific information along the supply chain.
- Small-size and low-cost (near-term goal of $0.05 per tag, moving to <$0.01) would drive to virtually all types of consumer goods



Roll of RFID Tags

RFID Tags for Pallets and Boxes

RFID Tags

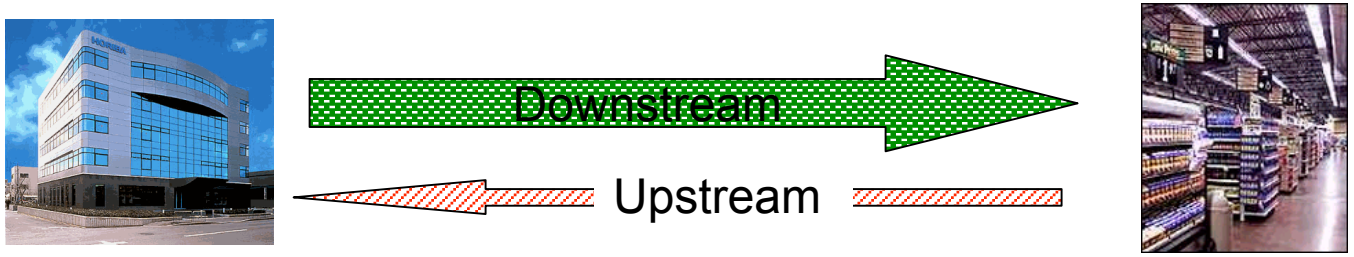
Companies Evaluating / Implementing RFID Solutions According to EPC & Industry Sources

Client	Industry Vertical	Application
• American Express	- Financial	- Contactless Payment System (ExpressPay)
• Best Buy	- Retail	- Track & Trace / Asset Management
• Coca-Cola	- Retail	- Track & Trace / Asset Management
• CVS	- Retail	- Payment System / Track & Trace
• Department of Defense	- Government	- Track & Trace / Chain of Custody
• DHL	- Transportation	- Track & Trace*
• Federal Express	- Transportation	- Track & Trace*
• General Mills	- Manufacturing	- Track & Trace
• HP	- Manufacturing	- Track & Trace / Asset Management
• Johnson & Johnson	- Manufacturing	- Track & Trace
• Home Depot	- Retail	- Track & Trace / Asset Management
• Kelloggs	- Manufacturing	- Track & Trace
• Kimberly-Clark	- Manufacturing	- Track & Trace
• Kodak	- Manufacturing	- Track & Trace
• Merck	- Pharma	- Track & Trace / Chain of Custody
• Micro Beef Technologies	- Ranching	- Track & Trace / Chain of Custody
• Mobil Speedpass	- Retail	- Contactless Payment System
• Novartis	- Pharma	- Track & Trace / Chain of Custody
• Pfizer	- Pharma	- Track & Trace / Chain of Custody
• Roche	- Pharma	- Track & Trace / Chain of Custody
• Schering – Plough	- Pharma	- Track & Trace / Chain of Custody
• Target	- Retail	- Track & Trace / Asset Management
• Tesco	- Retail	- Track & Trace / Asset management
• The Gillette Company	- Manufacturing	- Track & Trace
• Tyson	- Manufacturing	- Track & Trace / 300M cases per year
• UPS	- Transportation	- Track & Trace*
• Visy Paper	- Manufacturing	- Track & Trace
• …		

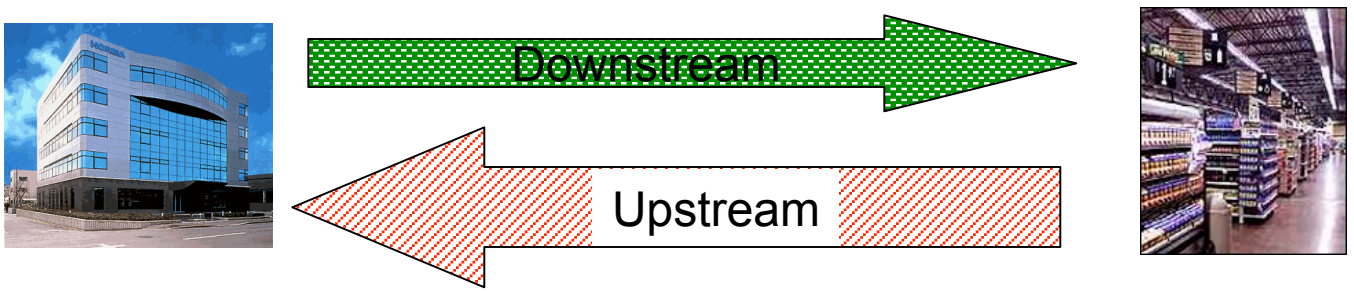
RFID - Network Implications

- With RFID, more information is at the network edge and will feedback to central sites (like distribution centers and corporate headquarters)
- Existing information exchange could reverse (i.e. more coming from the edge back to the central site rather than a pushed down)
- Would make existing network access systems, such as VSAT terminals and ADSL, inadequate for the new task
- Would drive SYMMETRICAL broadband deployment further to the edge

Today - More Information Flow from Corporate to Edge



Tomorrow - More Information Flow from Edge to Corporate



Object Naming Service (ONS)

- ONS tells computer systems where to find information about any object with an electronic product code (EPC) for RFID applications.
- Designed in a similar concept like a URL for the internet. Based in part on the Internet Domain Name System (DNS) – routes information to appropriate network endpoints
- The EPC means nothing without the ONS information about the actual product instance carrying the EPC.
- The ONS is accessed via IP networking in a distributed fashion
- The amount of data transactions for ONS service is expected to grow at a phenomenal rate.
  - Today the worldwide Internet handles 17 billion messages a day.
  - Several industry sources have estimated that the worldwide ONS network will need to handle approximately 4 quadrillion message a day by 2012 (note: item level tagging is assumed).

RFID Services

2) Managed Hosted Transaction-Based and/or client dedicated Electronic Product Code Information Service (EPCIS) store the read data at redundant IDCs for data protection, and secure data analysis and data access
3) Value added services provide security, track, trace, chain of custody, and other features across industry supply chains

AT&T BusinessDirect Portal

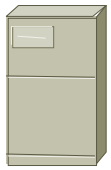
AT&T Hosted RFID EPCIS

1) Premises RFID services collect, filter, and send RFID Tag data

RFID Tag

Reader

Edge Server

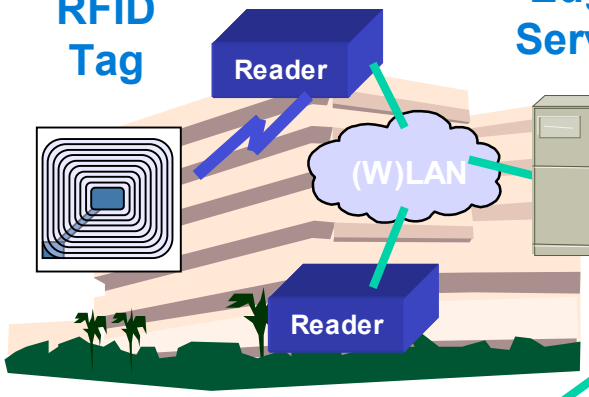


Value Added Services

(W)LAN

AT&T Network

Reader

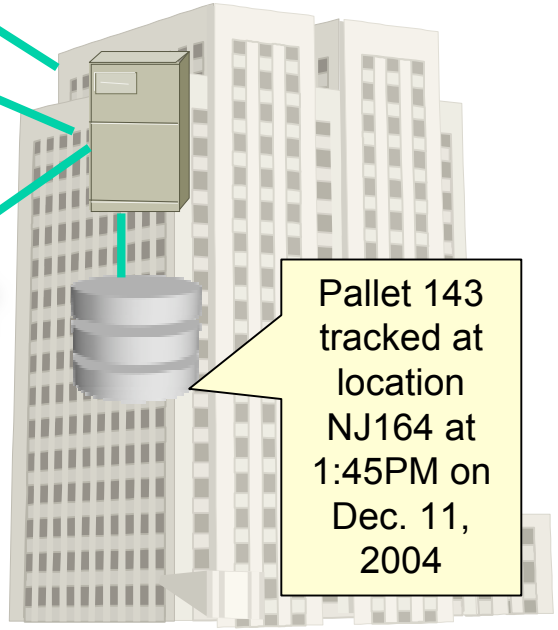


Client1 Factory

Client 3 Mobile Platform

Client2 Logistics Center

ClientN Retail Location



Pallet 143 tracked at location NJ164 at 1:45PM on Dec. 11, 2004

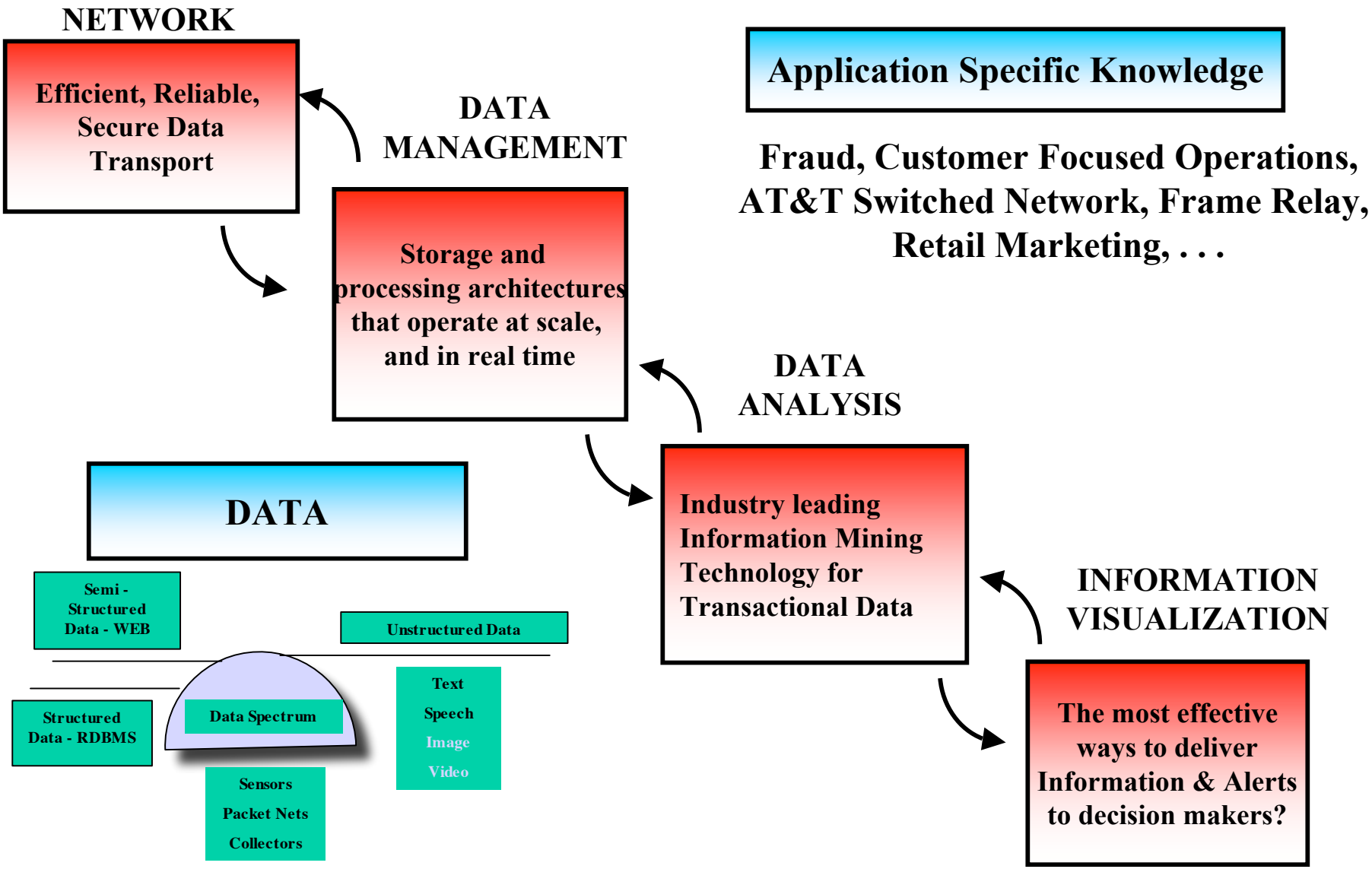
AT&T IDCs

Ubiquitous Computing: Research in Information and Software Systems

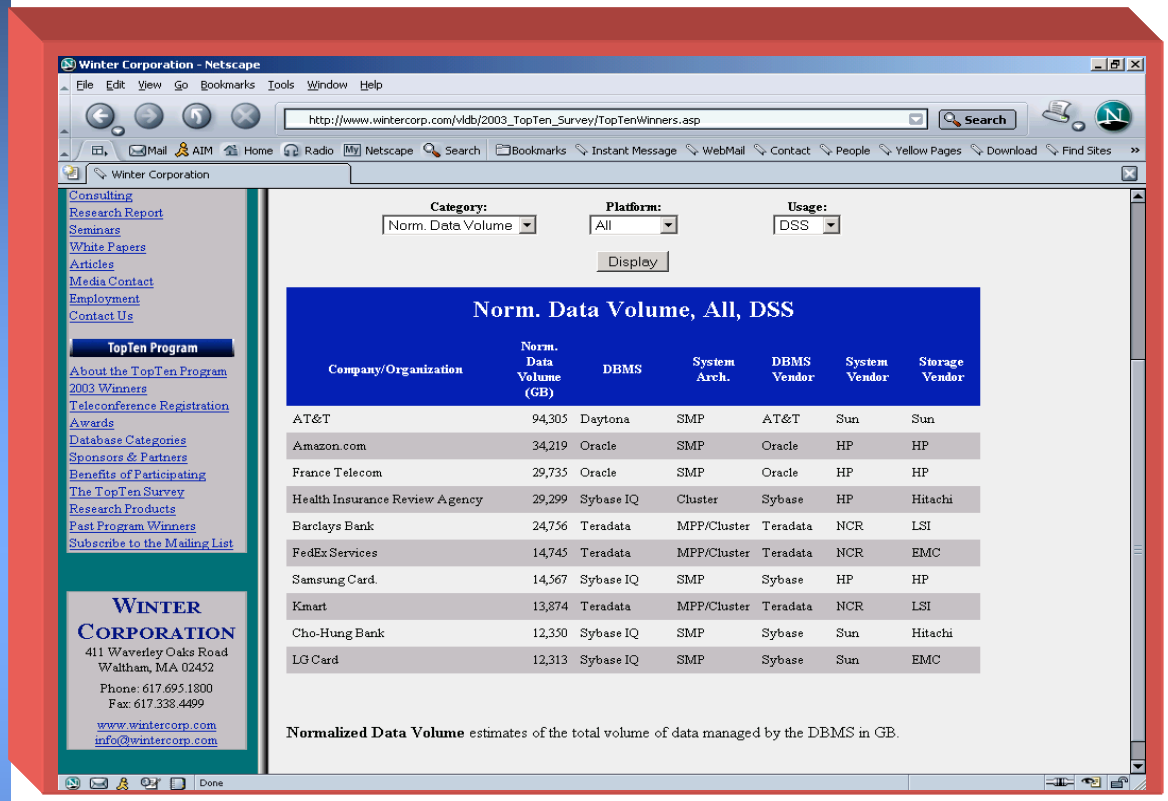
The Next Bottleneck - Information

- We are no longer CPU constrained, e.g. 5 GHz CPUs
- We are no longer memory constrained, e.g. multi-GB memories
- We are no longer disk constrained, e.g. 160 GB disk
- We are becoming less bandwidth constrained, e.g. cable, DSL, FSO, WiFi
- We could easily be constrained by our ability to extract useful information from massive amounts of data
- Ubiquitous computing means lots of data, and data of different types!

AT&T Data Mining Approach



Daytona: Managing Data at AT&T Scale

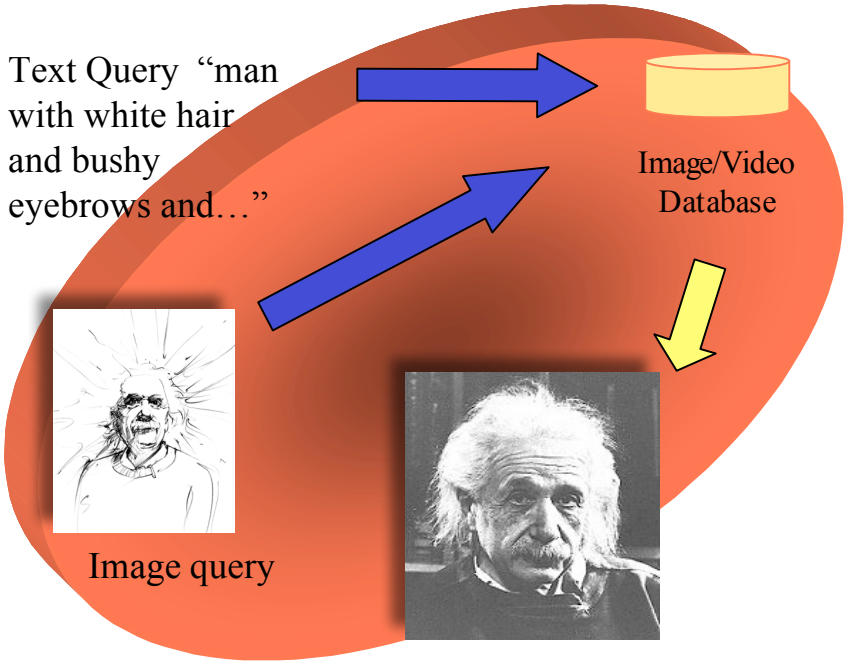


- **Massive amounts of data can be collected, but hard to manage in commercial DBs**
- **Daytona enables scalable data management**
  - –organizes and stores massive amounts of data on disk, supported by indices and a data dictionary
  - –permits concise expression of sophisticated queries
  - –provides answers to those queries quickly
  - –data in a concurrent, crash-proof environment
  - –proven reliability

Applications across AT&T:

- SCAMP – AT&T Call Detail Data Base of Record
  - largest publicly known data warehouse
- Global Fraud Mgt. System – All AT&T Call Fraud
- Traffic Analysis System (TAS) – IP Traffic Analysis
- STORM/FLOOD – Network Security Monitors
- Gigascope – IP Packet Monitoring & Analysis (OC48)

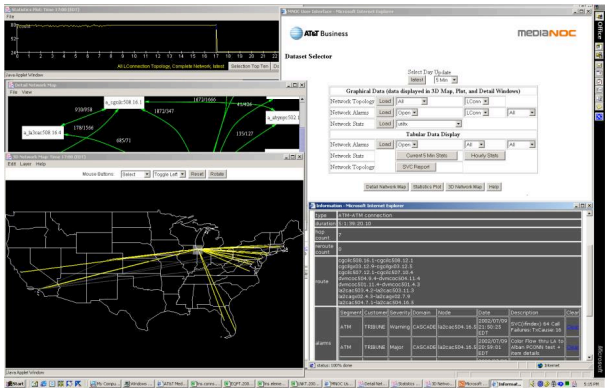
Analysis: Video and Image Data Mining



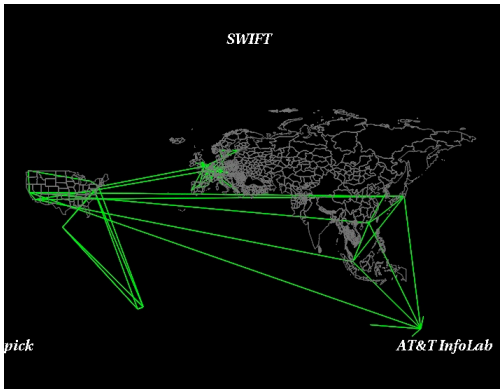
- Strengthen AT&T's hosting offers in the image/video space with higher value-added services
- Enhance AT&T's video conferencing portfolio with automatic indexing.
- Provide summarization services to broadcast video customers.

- Automatic annotation of large image and video databases for better content-based retrieval.
- Techniques for automatically labeling image and video content with descriptive text.
- Flexibility to support consumer-grade digital cameras, and compressed-domain processing tolerant to multiple compression formats.

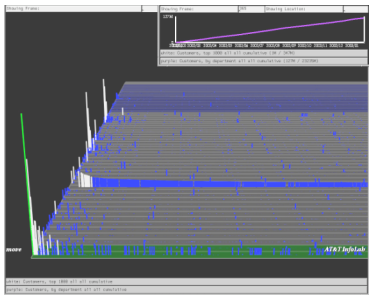
SWIFT: Visualizing Large-Scale Services



customer end-to-end views

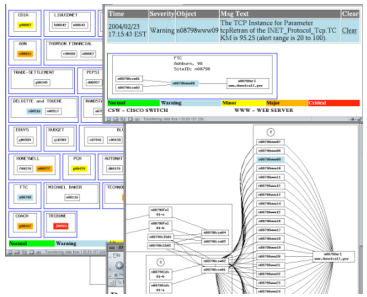


EMEA global network

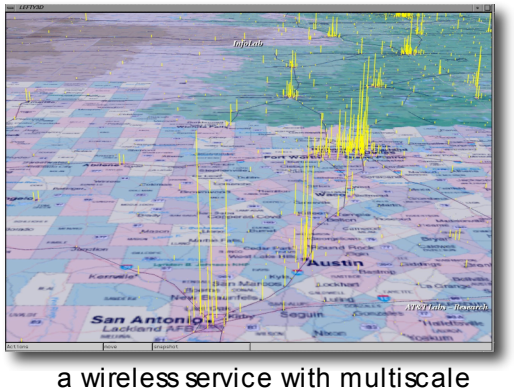


retail transactions

high-res aerial images



IDC customer view

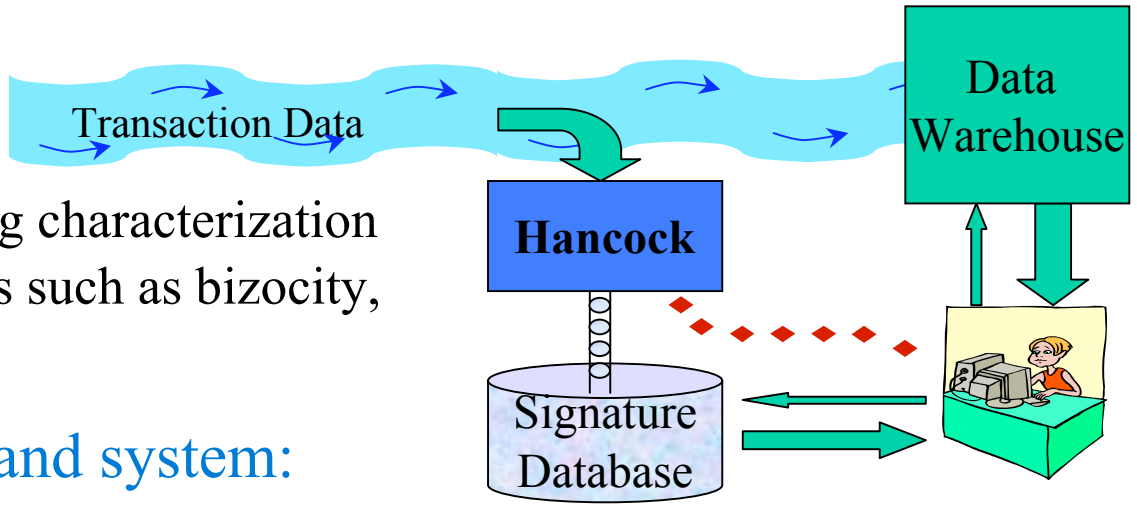


a wireless service with multiscale geopolitical map overlays

Project X-Ray

- Swift runs at full scale on data sets with hundreds of millions of items.
- It enables data integration in the human interface.
- It offers 3D graphics and animation for visual querying, navigating from a global view of the entire data set down to individual records.
- It works with both live data feeds and stored historical state simultaneously.
- Swift runs on anything from desktop clients up to large Powerwalls.
- Current work is to generalize using ODBC, JDBC, XML.

Large Scale Data Stream Processing



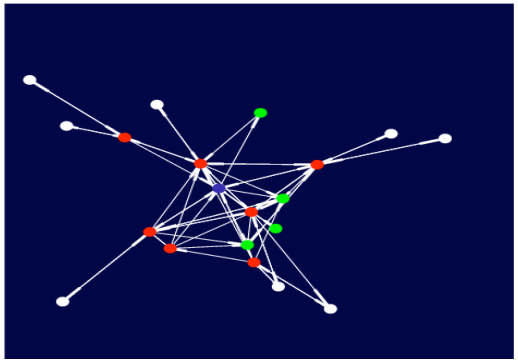
Signature: an evolving characterization of customers' behaviors such as bizocity, fraudicity, usage, etc.

Hancock language and system:

- Succinct specification of signatures.
- Data streams processed and stored with compression.

Community of Interest:

- Fraud detection, record linkage, etc.
- 228M phone #'s, 120 bytes per #.
- 7GB collection.
- Update daily in 2 hours.



- Inbound calls
- Known fraudster
- Outbound calls

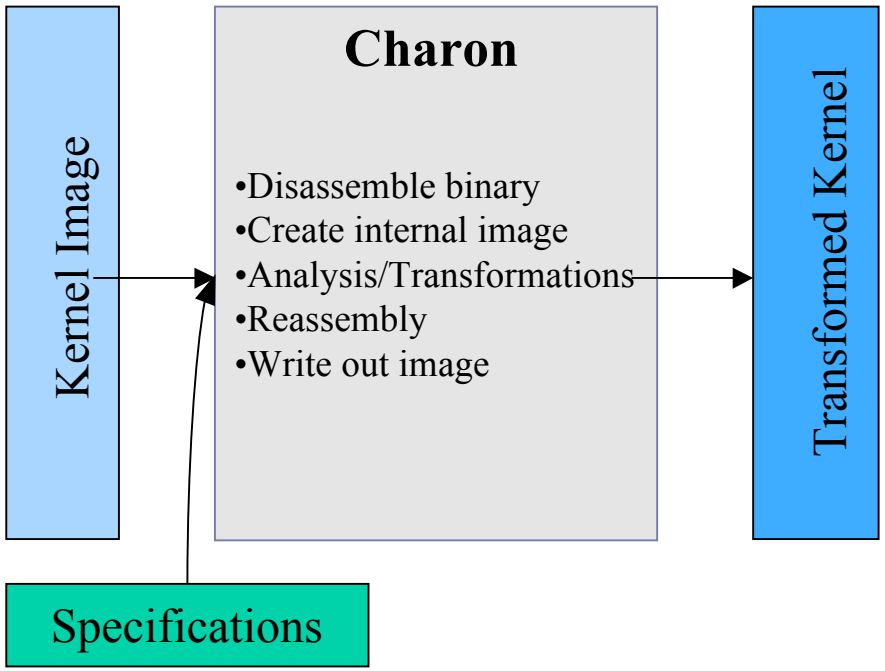
Cassyopia: Software System Optimization

Compiler-assisted holistic system optimization.

- **Goals**
  - Optimize across address spaces and different types of address spaces (e.g, user processes+kernel).
  - Optimize for different metrics, including performance, memory footprint, fault tolerance, security.
  - Optimize across address spaces that execute on separate machines.
  - Both static and dynamic optimizations.
- **Use compiler optimization techniques in novel ways**
  - Most of the work based on the PLTO, a binary rewriting tool for the IA-32 architecture.

Charon: Automated Kernel Specialization

Perform automated kernel transformations.



- **Uses**
  - Kernel specialization for small or specialized devices such as sensors, motes, routers, cell phones, etc. (*kernel compaction*).
  - To expose OS state to application or middleware to enable, e.g, adaptation.
- **Tool being built by modifying PLTO.**

Conclusions

Ubiquitous computing means more endpoints and more data.

- **Challenges**
  - Network architectures and management.
  - Information handling and mining.
  - Software and systems.