Telecom Technology for the 21st Century

Lawrence Rabiner
Rutgers University and the University of California at Santa Barbara
# Key Technology Directions

<table>
<thead>
<tr>
<th>20th Century</th>
<th>21st Century</th>
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<tbody>
<tr>
<td>New Access</td>
<td>narrowband voice</td>
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<tr>
<td>New Network</td>
<td>circuit-switched</td>
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<tr>
<td>New Traffic</td>
<td>circuit traffic model</td>
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<tr>
<td>Engineering</td>
<td></td>
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<tr>
<td>New Platforms</td>
<td>intelligent network elements</td>
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<tr>
<td>New Operations</td>
<td>people-oriented</td>
</tr>
<tr>
<td>New Devices</td>
<td>telephone, computer</td>
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<td>New Services</td>
<td>voice, data</td>
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Broadband Initiatives

• **Infrastructure:**
  - provide broadband access everywhere (at home, on the road, in the office) and for the business enterprise
  - build next generation IP network to efficiently and reliably handle broadband traffic volumes and advanced services

• **Operations:**
  - provide capability to automatically manage customers, end-to-end networks, and services
  - real time data publishing, billing, provisioning, order tracking, customized service, on-demand service

• **Services:**
  - platform capabilities for service creation, content distribution, service management
  - new and enhanced services for business, consumer, wireless
Cost Issues with Network
## Network Cost Structure

<table>
<thead>
<tr>
<th></th>
<th>$ Cost / Minute</th>
</tr>
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<tbody>
<tr>
<td><strong>Access Charges</strong></td>
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<td><strong>Operations &amp; Other Costs</strong></td>
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Network Cost Structure

$ Cost / Minute

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Circuit vs. IP Cost Trajectory

- Circuit
- IP

Year:
- 1999
- 2000
- 2001
- 2002
- 2003

$/Connection

Networking the New Economy
Effects of Moore’s Law (and Beyond)
Where is Technology Taking Us? Growth!

Technology Growth Rates over 10 years:
- WAN Bandwidth: 10 mos.
- Processor Power: <1.5 yrs.
- LAN Bandwidth: 1.7 yrs.
- Disk Transfer Rate: 2.2 yrs.
- I/O Bus Rate: 2.5 yrs.
- Disk Seek Rate: 10 yrs.

Transport, Switching/Routing Moving from Electronics to Optics
Growth in Voice and Data
Driving Forces - The Internet Explosion

**Voice & Data Traffic Growth**

- **Voice:** Now 23x
- **Data:** Now 5x

**Time:** 1995, 2000, 2005

---

**Circuit & IP Voice/Fax Revenue Growth**

- **Circuit Voice/Fax:**
  - 1995: $90 B
  - 2000: $70 B
  - 2002: $50 B
  - 2005: $10 B

- **IP Voice/Fax:**
  - 1995: $5 B
  - 2000: $5 B
  - 2002: $10 B
  - 2005: $70 B

Source: Probe Research
Growth in Network Traffic

Data and Voice

Terabytes per Day

Year

Voice Traffic:
576 TB/day
Data Traffic:
1178 TB/day at YE’00,
2136 TB/day at YE’01 (estimated)
AT&T Network Services
Terabytes of Demand

Private Line

Frame Relay

ATM

Internet / IP

YE’00: 1178 TB/day
YE’01: 2136 TB/day

YE 2000:
PL-1000 TB/day
FR-28 TB/day
ATM-40 TB/day
IP-110 TB/day

CAGR:
PL-67%
FR-50%
ATM-100%
IP-214%
AT&T’s Daily Traffic Load

Year

'97 '98 '99 '00 '01 '02 '03 '04

0% 20% 40% 60% 80% 100%

Circuit Switched

Private Line

Frame

IP

ATM
Impact of the Internet on the Network
The Internet Explosion (5/2002)

- 2,000,000,000 Web Pages
- Internet Hosts 150,000,000
- 500,000,000 Worldwide Users
- CAGR since 1998 100%
Decreasing Technology Adoption Rates

Time To Reach 10 Million Customers

- Pager: 41 Years
- Fax Machine: 22 Years
- VCR: 9 Years
- Cellular Phone: 9 Years
- CD-ROM: 7 Years
- PC: 6 Years
- WWW: 4 Years
- New Browser: 1 Year

Sources: Apple, AirTouch Cellular, Info Tech and USA Today
E-Commerce Revenue

--- Commerce on the Web will reach $350 Billion by 2002.

Source: Forrester Research, BancAmerica Robertson Stephens
Access Architecture for Home, Business and on the Road
The Local Access Dilemma

how do we efficiently connect The Last Mile with?

Subscribers

customer premises

ISP
VPN
PSTN
ATM
FR
Access Alternatives: Summary

- Data Rate:
  - 10G
  - 1G
  - 100M
  - 10M
  - 1M
  - 100K

- Services:
  - Local Service
  - Wireless Service
  - Business Service
  - Angel
  - Mobile
  - DSL
  - Broadband Radio
  - Cable
  - Fiber

- Peak Rates:
  - T1
  - DS3
  - OC3
  - OC48
  - OC192

- High-Speed Internet Access: Consumer and Business

- AT&T Logo
Cable Network Evolution

Conventional HFC

- Hub
- FN
- Migration
  - 1,200 HP
  - 300 HP
- Bands:
  - Analog video
  - DTV
  - Data Voice
- Frequencies:
  - 5 MHz to 40 MHz
  - 550 MHz to 624 MHz
  - 750 MHz to 1 GHz
- Bandwidth:
  - (35 MHz - ingress)/300 HP
  - 3 X

Advanced Cable Network

- Hub
- MN
- mFN
- mFN
- Migration
  - 800 HP
  - 100 HP
- Bands:
  - Analog video
  - DTV
  - Data Voice
- Frequencies:
  - 10 MHz to 45 MHz
  - 550 MHz to 624 MHz
  - 750 MHz to 1 GHz
- Bandwidth:
  - 35 MHz/100 HP
  - 6 X
  - 10 X
  - Additional

Phase 1

Phase 2
# Mobile Cellular Wireless: A Short History

<table>
<thead>
<tr>
<th></th>
<th>1st Generation Ubiquity</th>
<th>2nd Generation Digital</th>
<th>3rd Generation Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time</strong></td>
<td>1980s</td>
<td>1990s</td>
<td>2000s</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Analog</td>
<td>Digital (TDMA,CDMA)</td>
<td>Packet</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>Voice, Data Modems</td>
<td>Voice, Circuit + Packet Data</td>
<td>Multimedia</td>
</tr>
<tr>
<td><strong>Systems</strong></td>
<td>AMPS, TACS ...</td>
<td>IS-136, IS-95, GSM, PDC, ...</td>
<td>EDGE, W-CDMA, cdma2000, ...</td>
</tr>
<tr>
<td><strong>Data Rates</strong></td>
<td>10 Kb/s</td>
<td>~ 20 Kb/s</td>
<td>384 Kb/s and higher</td>
</tr>
<tr>
<td><strong>Key Issues</strong></td>
<td><em>viability</em>--would cellular work</td>
<td><em>coverage and capacity</em>--would cellular meet demands</td>
<td><em>wireless web, location based services</em>--what data service drives demand</td>
</tr>
</tbody>
</table>
Wireless Web Services

- **Communication**—voice telephony, video telephony
- **Unified Messaging**—Instant Messaging, Short Message Services, e-mail, chat
- **Video Services**—instant digital photos, live views from video cams, live video support for home/office repairs, movie previews
- **Mobile Commerce**—hotel reservations, car rental, movie tickets, small purchases (Coke machine)
- **Data Services**—horoscopes, comics, animated Pokemon characters, checking flight departure and arrivals
- **Location-Based Services**—directions, find nearest ATM machine, find best traffic route
- **Time Critical Services**—investments, new headlines and stories, business updates
- **Status Monitoring**—alerts and alarms
- **IP Telephony, Video Conferencing, Video Telephony**
- **Streaming Audio and Video**—web radio, web TV, jukebox
- **Games**—find nearest players and join in
3G Mobile Terminals

**Feature Phone**
- Voice centric design
- WAP browser
- Bluetooth connectivity

**Integrated Handhelds**
- Data centric design
- Voice capability

**Video Phone**
- Unique design concepts
- Color camera and screen
- Integrated applications

**PC Cards**
The Network of the 21st Century
20th Century Network Design

Circuit Switched Voice and Data

Packet Switched Data (Frame, ATM, IP)

PSTN Signalling

customized network for each service (Voice, Frame, ATM, IP)
Networking the New Economy

Current Networks (20th Century)

- ATM/Frame
- Wireless
- TCG/CERFnet
- Voice
- IP Backbone
- TCI

• integrating backbone layer to merge all networks
• need to integrate OSS for each network and service
21st Century Network Design

Packet Routed Multimedia
Data

Shared High Speed Access Networks
Network Priorities

- **Growing the Network**
  - integration of multiple formats, rates, services
  - high speed access/multiple access
  - OTS OC-192/OC-768 backbone transport
  - $\lambda$-routers => intelligent optical switching (IP backplane control)
  - web hosting centers
  - Intelligent Content Distribution (ICD)

- **Improving Reliability and Performance**
  - network scalability => number of endpoints, number of nodes, speed
  - classes of service via DiffServ, IntServ, MPLS
  - QoS => predictable performance (SLA), VPN, traffic classes, admission control
  - policy-based networking, directory-enabled networking (DEN)
  - network traffic engineering => multi-service fractal traffic

- **Adding Features and Intelligence**
  - IPv6 (bigger address space, class of service, security)
  - PKI, IP-sec, privacy, authentication
  - multicast traffic control

- **Operating Smarter and More Efficiently**
  - scalable network management tools => BRAVO, netdb, mmdump, Marvel, Minc
  - information model of network => access and view traffic, services, bills
  - process improvements => instant provisioning
Core/Tributary Baseline Architecture

**Core:**
124 4E Offices

**Tributary:**
450 Regional Offices
Functionality Migration

Migration of Functionality to Element With More Rapid Price-Performance Improvement

Reducing Overlapping Functionality
Networking the New Economy

IP Transport Network Evolution
(Services View)

Switched Services

IP Layer (Router)

Circuit Switch Layer

W-DCS Layer

B-DCS Layer (S-DCS, DCS-3/3)

SONET Layer (ADM)

Optical Layer (DWDM)

Private Line Services

Aggressive Migration to VLL

IP Layer (Router)

OLXC Layer

Optical Layer (DWDM)

Switched Services

VoIP

Switched Data

Private Line Services

DS-1 (multiplexed into DS-3)

OC-12

DS-3, OC-3, OC-12

DS-3, OC-3, OC-12

DS-3, OC-3, OC-12

OC-3, OC-12

OC-48

OC-48

OC-48

IP Restoration (MPLS)

Mesh or Ring Restoration

AT&T
Networking the New Economy

Next Network Architecture

- **Customer Premises**
  - T1
  - T3
  - OC-3
  - OC-48

- **MSP**
  - OC-192

- **Intelligent Optical Switch**
  - Cisco/Redback
  - Intelligent Optical Switch
  - OC-48
  - OC-192

- **DWDM**
  - 16, 32, 80 Wavelengths
  - 160
  - OC-48, OC-192
  - OC-192, 40Gbps

- **Next Network Architecture**
  - MSP: Multi Services Platform

- **Route Miles**
  - Local Fiber: 16K
  - Next-Gen: 3K
  - Core Fiber: 42K
  - Local Rings: 6K
  - OC-48 Sections: 1K

Optical Switching:
- Point & Click Provisioning
- ½ Price, Floor Space and Power
- Mesh Restoration

MSP: Multi Services Platform
Network Services/Network Engineering
Key Network Services

- **QoS (Quality of Service)**—how can you guarantee packet delivery over an IP (best effort) network
- **VPN (Virtual Private Networks)**—how can you create secure connections between sites (point-to-point), across firewalls, and across multiple infrastructures (private nets, Internet)
- **CDN (Content Distribution Networks)**—how can you move both static and dynamic content across the network (to network edges, to local POPs, to service centers, to hosting centers, etc) to reduce congestion at every point in the network
QoS Solutions

- **Virtual Leased Lines (VLL)**—permanent virtual circuits
- **ATM** with Class of Service routing—switched virtual circuits
- **Integrated Services (IntServ)**—assigns traffic class to each flow, uses RSVP (Resource Reservation Protocol) to reserve end-to-end network resources
  - cannot guarantee resources
  - works on a per flow basis (no aggregation of multiple flows with same traffic class)
  - doesn’t scale => wastes network resources
- **Differentiated Service (DiffServ)**—appends tag to each packet with service class
  - allows aggregation of packets with common tags
  - more efficient use of network resources
- **MPLS (Multi-Protocol Label Switching)**—attach label (tag) to packets at edge routers so that IP packet headers don’t have to be read at each hop
  - in between routers only read MPLS tags
  - label swapping at intermediate routers leaves a packet route trail for future packets
Diff-Serv QoS End-to-End (MPLS-Based)

Four classes of service (2002)

- VIRTUAL LEASED LINE (VLL)
- REAL-TIME ASSURED
- ASSURED
- BEST EFFORT

 Guaranted Bandwidth
 Controlled Delay Jitter
 VoIP
 Better Packet Loss
 Time sensitive

Basic SLAs (Availability, Delay, Packet Loss)
Business/Enterprise Networking Issues
What Customers Will Want

Virtual Private Global Networks
**IP Virtual Private Networks (VPNs)**

Partitioning a shared infra-structure to create a virtual network that provides participants

- Connectivity
- Traffic Isolation
- Access Control
- QoS
- Security.

[Diagram showing shared infrastructure and business networks connected to it]
AT&T Ecosystem for Media

e-Media benefits from e-Business solutions
Content Delivery Networks (CDN)

Distributed System improving ‘net Performance, Reliability, & Economics’

Features and Services

- Accelerate web page downloads
- Bring content to the edge of network
- Scale capacity on demand
- Multicast routing
- Multimedia portal for Interactive TV
- Reduce single point of failure vulnerabilities
ABS Functional Structure

Business Unit

Mary Jane McKeever

Robin Young

Barbara Peda

Robinson Young/Barbara Peda

Prof. Services

Managed Service (VPN, VoIP, QoS, CDN, Hosting)

Connectivity (PL, FR, ATM, IP)

Systems Architecture, Common Framework--OSS, Security, Infrastructure, Info-Data
OPERATIONS

(Database Technology, Data Mining, Visualization, Data Compression, Signatures, Query Languages, Data Analysis, User Interfaces)
Learning From Data—Data-Driven Business Operations and Network Management

- **Data Hoarding**—measure the right things about the way the company does business, severely restrict access to the data, then store it away safely (sometimes forever), look at it only when things go wrong.

- **Data Publishing**—make all the data within the company broadly available throughout the corporation, encourage people at all levels to study and use the data to provide competitive advantage, learn how to run the business more efficiently based on lessons learned from the data.

  - *everyone in the organization is on the same ‘web’ page*

- Understand the market first
- Act on changing market conditions with more insight than your competition
- Do it consistently

WIN!!
PSTN Data

- Store CDR (Call Detail Records) on 350 million wired and wireless calls/day for up to 24 months
  - generate *detailed bills* by service, customer, network
  - detect *fraud* from customer (usage) signatures
  - detect consumers whose *calling patterns have changed*—e.g., they are running a business from their home at consumer rates
  - detect business customers who are using *multiple carriers*—i.e., Low Toll Notifier alarms
  - detect business customers whose *lines are being used fraudulently*—i.e., High Toll Notifier alarms, Net Protect (PBX hacking)
  - detect *subscription fraud* from customer Communities of Interest (COI)—fraudsters tend to communicate with other fraudsters
  - detect *phantom churn*—i.e., cell phone customers who have closed an account and opened a new one, in order to get a new cell phone
  - detect *movers*—i.e., people who have terminated service at one place and initiated service somewhere else, but with the same Calling Circle (COI patterns) of friends
  - detect *Calling Card Fraud*—rapidly
  - detect *International Calling fraud*—rapidly
  - do *Instant Marketing* based on immediate response to advertising—10-10-345 marketing campaign
  - support *peering agreements* between carriers based on actual traffic patterns—protect against arbitrage arrangements
IP Traffic Data—2100 TB/day

- generate *pricing plan* that reflects actual network usage—i.e., WorldNet plan for $4.95/month low usage customers
- enable the GNOC to *display network traffic patterns* for any customer, any service, and any network traffic type (IP, ATM, FR, PL)
- enable the customer to *display their own network traffic patterns* for any link or router on the AT&T Network
- enforce *SLA agreements* based on measured data
- manage *dynamic network provisioning* based on measured traffic patterns
- *balance router, switch traffic dynamically*
- make *router tables consistent* and up-to-date
- detect *link and router failures*
Finding Insights Visually
Networking the New Economy

AT&T Labs – InfoLab
Devices—The Broadband Phone
Broadband phone
Enhancing everyday communications

Philosophy
It's a phone not a computer

Architecture
100% network centric

Cute feature
Both parties can see the same thing

Sound bite
Simple phone
Smart network

Enhanced applications
- Home shopping
- Reservations & Information
- Photo Albums
- Chat ‘n’ draw
- Fax & Mail
- Live video
- Web browsing

Remote graphics protocol
IP telephony

The screen comes from the network
The services are on the screen
The network is the phone

No operating system
No web browser
No downloadable code
Nothing to go wrong
Networking the New Economy

Phone Dialer  Directory  Notepad  Message Flash
Calendar  Calculator  Photo Album  Cameras
Music  Chess  Minesweeper  Piano
Pizza  Fax and Mail  Browser

Thu Jul 13 23:05:34

Clear

1  2  3
4  5  6
7  8  9
*  0  
#

Phone 201
IP Services
Families of IP Services

- **Service works well on narrowband connections**
  - traditional voice calls
  - email, voice messaging, FAX
  - low speed data services

- **Service works on narrowband connections; it works a lot better on broadband connections**
  - Internet browsing
  - streaming audio
  - streaming video
  - software downloads
  - network storage of photos, PIM

- **Service only works on broadband connections**
  - video on demand (MPEG-2, HDTV)
  - virtual reality
  - digital CATV
  - browsing catalogs, news, TV shows
  - streaming CD quality audio
  - interactive video agents
Giving Machines High Quality Voices and Faces

U.S. English Female:  
U.S. English Male:  
Spanish Female:  

‘Natural Speech’
VTTS Demo

Au Clair de la Lune       Virtual Secretary
Voice Dialogue System
Customer Care Scenario
Voice-Enabled Service Challenge

Problem:
How do we provide a natural language voice interface to take people out of ‘IVR Touch-Tone Hell’ and automate tasks like customer care.

Solution:
Exploit an intelligent voice dialogue system with a modern high quality speech synthesis system.

Business Implication:
HMIHY (How May I Help You) — a fully automatic system for voice-enabled applications with extremely high performance on tasks like Customer Care and Help Lines.

* IVR—Interactive Voice Response
IVR Touch-Tone Hell

If you want Watson, please press one
Customer Care IVR and HMIHY

**Customer Care IVR**

- **10 seconds**
  - Sparkle Tone
  - "Thank you for calling AT&T…"

- **30 seconds**
  - Network Menu

- **13 seconds**
  - LEC Misdirect Announcement

- **26 seconds**
  - Account Verification Routine

- **58 seconds**
  - Main Menu

- **38 seconds**
  - LD Sub-Menu

**HMIHY**

- **Sparkle Tone**
  - "AT&T, How may I help you?"

- **20 seconds**
  - Account Verification Routine

- **8 seconds**
  - Reverse Directory Routine

**Total Time to Get to Reverse Directory Lookup:**

- AT&T: 2:55 minutes!!!
- HMIHY: 28 seconds!!!
### HMIHY—How Does It Work

- Prompt is "AT&T. How may I help you?"
- User responds with totally **unconstrained** fluent speech
- System **recognizes** the words and determines the **meaning** of users’ speech, then routes the call
- **Dialog** technology enables task completion
Architecture for Natural Spoken Dialog

User Speech → ASR (Automatic Speech Recognition) → SLU (Spoken Language Understanding) → Dialog Manager

- Acoustic Models
- Language Models
- Salient Grammar Fragments
- Inheritance Hierarchy

Dialog Response → Meaning → Dialog Manager

Play Prompt
Example Dialogs

- Irate Customer
- Rate Plan
- Account Balance
- Local Service
- Unrecognized Number
- Threshold Billing
- Billing Credit
How Well Does It Work

• **HMIHY delivers expected value**
  - accurate classification and routing of calls; classification accuracy measures show customers are being directed to correct Service option
  - increased participation rates; customers are not bailing out of the service
  - reduced cost of service--$1.00/minute for live agent versus $0.13/minute for automated service agent

• **Improved customer satisfaction**
  - service is faster, easier to use, and more intuitive than IVR alternative

• **HMIHY provides new opportunities for automation of customer calls via self-service modes**

• **AT&T plans to use HMIHY for its 0300 Consumer Care service with 4000 lines of service by late 2001**
Telecommuting and Remote Call Centers--the Future of Remote Access
Virtual Communication Services - Office & Agent

**VCS-Office**: “taking your desktop anywhere”—telecommuting solution

**VCS-Agent**: “customer contact agent working anywhere”—virtual call center solution

- based on WISL (Wideband Internet Sales Link) and ROSE (Remote Office Services)
- emulates ISDN telephone (with all the calling features) via ‘softphone’ simulated on PC
- provides secure, private, Virtual Private Network access to corporate network (and PBX) using a hardware device (Yorkie)
## Work Anywhere Service Concepts

<table>
<thead>
<tr>
<th>ROSE (Telecommuter)</th>
<th>WISL (Virtual Call Center)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Virtual Office that allows workers to have the <em>same functionality</em> they have in the Office with a <em>PBX</em>.</td>
<td>A Virtual Contact Center that allows agents and supervisors to have the <em>same functionality</em> they have in the Contact Center with an <em>ACD</em>.</td>
</tr>
<tr>
<td>The <em>AT&amp;T network</em> directs calls to/from those workers.</td>
<td>The <em>AT&amp;T network</em> directs calls to/from those agents and supervisors.</td>
</tr>
<tr>
<td>The <em>Internet link</em> provides the customer’s application and performs call control.</td>
<td>The <em>Internet link</em> provides the customer’s application and performs call control, screen pops, agent/supervisor chat, screen capture, etc.</td>
</tr>
<tr>
<td>A <em>Softphone</em> provides an Office multi-function phone.</td>
<td>A <em>Softphone</em> provides a Virtual Contact Center multi-function phone.</td>
</tr>
<tr>
<td>The <em>Moat</em> provides the worker with secure and private access to the corporate network and to the ROSE server.</td>
<td>The <em>Moat</em> provides the agent/supervisor with secure and private access to the corporate network and to the WISL server.</td>
</tr>
<tr>
<td>Workers have full <em>Mobility and Messaging</em> capabilities.</td>
<td>Supervisors (<em>service observers</em>) can listen, watch, and interact with calls from anywhere.</td>
</tr>
</tbody>
</table>
Virtual Communication Services

*basic architecture*

- Telephone Network
- AT&T Virtual Communication Services Server
- PBX/ACD
- CTI
- HTTP
- Full Featured Softphone
- JAVA Applet

Networking the New Economy
REMOTE OFFICE SERVICE (VCS-Office) SOFTPHONE

Message Waiting

Caller ID

Speed Dialing

Multiple Line Appearances

Hold, Transfer, Conference
REMOTE OFFICE SERVICE (VCS-Office)
Virtual Office

“Secured” Internet

HOST
PBX
CTI
CABLE
TV
MOBILE WORKER
CALLER

PBX STATIONS

REMOTE WORKER
appears as a station
off the premises or network PBX
with full call control, application,
and messaging capabilities

MOAT
AT&T VCS
Server

CALLER

PBX

CableModem

Softphone

AT&T VCS
Server

Moat
YORKIE IMPLEMENTATION OF THE MOAT

- Bypasses Windows environment
- High performance using a dedicated box
- Off-the-shelf hardware & software components
- IP tunnels remotely administered
- IPSec security
- Portable

- 5.6” x 4.9” x 1.25”
- Intel 220 MHz StrongARM processor
- 32 MBytes DRAM; 1 MByte Flash memory; CompactFlash socket (4-340 Mbytes)
- 2 ethernet ports & serial port; v2 has internal modem
- Linux operating system; Moat software (FreeS/WAN, ssh, xntpd, dhcpd)
CALL CENTERS
3,000,000 total seats in U.S.
100,000,000,000 AT&T minutes/year
Future Broadband Services

- videoconferencing, video mail, video meeting notes
- multimedia access to documents, images, sound files, movies
- searchable, browsable multimedia documents
- virtual reality experiences in games, entertainment, sports events, conferences
- and much, much more
Virtual Presence: Multimedia Call of the Future

- Collaborative Work
- Multimedia Messaging
- Multimedia 800 Customer Service
- Image Networking Services
- Multimedia Information Storage/Retrieval
- Virtual Corporations Multimedia Virtual Networks
Summary

- **Broadband access** is coming to the office, the home, and eventually on the road via 3G and 4G wireless technologies.
- The *network will be ready* to meet the heavy demands of both real-time (voice, video) and non-real-time broadband traffic.
- *Operationally* we will be ready to manage the network, the services, and the customers with a new generation of services based on real-time access to published data.
- **Broadband services** will stoke the pipes and continually push the rates at which customers will demand access to the network.