Connective Middleware for Next-Generation Campus Communications

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Voice

- The dominant real-time communications medium for homo sapiens
  - Handy for communicating in the dark
  - A product of evolution
  - Technology won't change this!

- “Killer" network app for O(100) years and for foreseeable future
Long promised, long delayed, still inevitable
- Has happened in the core
- Happening now for residential / enterprise

Enterprise VoIP Drivers
- Cost, cost, cost, cost, cost
- Why have a giant switch, 2 networks, 2 staffs, etc.? 
- Voice is just another network application

Enterprise VoIP Dampers
- QoS, 911, CALEA, USF, FUD
- Primary damper: too little user pull?
- Or maybe, too much...
Dude, Where're My Customers?

- Voice was once revenue-generating
  - No longer
- Users have adopted consumer services to meet personal / profession needs
  - Cellular
  - AIM, YIM, MSN, ...
  - Skype, FWD
- Can universities develop and deploy new campus communications services and recapture these customers?
Real Story is Decentralization, Not Convergence

- IP communications revolution is decentralizing telecom
- Small, interoperable modules with IP and open standards in between
- Far more options
  - No longer a binary choice between PBX and Centrex
- How should universities exploit these new opportunities to...
  - Enhance the campus life experience
  - Facilitate collaborative research
  - Support educators / students
“Advanced” Voice

- Many ways to do better than POTS

- Potential dimensions of improvement
  - Fidelity
  - Privacy
  - Addressing
  - Mobility
  - Survivability
  - Integration with IM, video, etc.
  - Presence
  - 911
Visions of the Future

What vision of advanced voice-centric communications should we work towards?

- Honestly, I have no idea!
- We should be modest about making predictions
  - ...especially about the future.
  - ...especially about users.

So, how can we nurture advanced VOIP?

Before answering this question, it’s useful to consider the history of earlier communications technologies...
Early History of the Telephone

For the first 30 years of the telephone, promoters struggled to identify the killer application that would promote its wide adoption by home owners and businesses. At first the telephone was promoted as a replacement for the telegraph, allowing businesses to send messages more easily and without an operator. Telephone promoters in the early years touted the telephone as a new service to broadcast news, concerts, church services, weather reports, etc. Industry journals publicized inventive uses of the telephone such as sales by telephone, consulting with doctors, ordering groceries over the telephone, listening to school lectures and even long distance Christian Science healing! The concept that someone would buy the telephone to chat was simply inconceivable at that time.

Bill St Arnaud’s summary of C. Fischer’s book *America Calling*
Email

- The popularity of email was not foreseen by the ARPANET's planners. Roberts had not included electronic mail in the original blueprint for the network. In fact, in 1967 he had called the ability to send messages between users “not an important motivation for a network of scientific computers” . . . . Why then was the popularity of email such a surprise? One answer is that it represented a radical shift in the ARPANET's identity and purpose. The rationale for building the network had focused on providing access to computers rather than to people.

  J. Abbate, *Inventing the Internet*

Peer-to-peer file sharing

- Again, not foreseen
- Essential ingredients: Internet2 connectivity + directory services (Napster, etc.)
And the Moral Is…

- Business and technology leaders…
  - …have a poor track record of predicting how new communications technologies will be used
  - …tend to underestimate social or seemingly “frivolous” uses of new technologies and overestimate the importance of “content”

- Users are highly motivated to communicate with each other, if only they can connect
Campus-Enabled P2P

- **P2P file-sharing explosion**
  - Internet2's network connectivity + Napster's middleware = P2P FS Explosion

- **Similar potential for real-time apps**
  - Skype community > 1,000,000 (simultaneously connected users) and growing

- **We can sit back and let this happen or we can manage the chaos in a way that leverages our strengths and addresses our unique needs**
## Today: Eager Users, Great Network, Some RTC Apps

- **Alice**: User
- **Bob**: User
- **Host**: Host
- **Campus**: Campus
- **Internet2/GigaPoP/ASP**: Network-Layer Connectivity
- **APIs**: Applications
- **Codecs**: Codecs
- **Signaling**: Signaling

### Diagram:

1. **Network-Layer Connectivity**
   - User
   - Host
   - Campus
   - **Internet2/GigaPoP/ASP**
   - Campus
   - Host
   - User
   - **high-performance, end-to-end IP transit**

2. **Applications**
   - APIs
   - Codecs
   - Signaling

The diagram illustrates the connectivity between users, hosts, campuses, and the network layers, highlighting the role of APIs, Codecs, and Signaling in high-performance, end-to-end IP transit.
Connectivity Through 3\textsuperscript{rd} Parties, Campus Islands, and PSTN

Applications

Alice

APIs

Campus VoIP/Video Systems

Bob

APIs

3\textsuperscript{rd} Party Matchmakers (Skype, AIM, YIM, MSN)

Network-Layer Connectivity

User

Host

Campus

PSTN

high-performance, end-to-end IP transit

Campus

Internet2/GigaPoP/ASP

Host

User

Applications

Alice

APIs

Campus VoIP/Video Systems

Bob

APIs

3\textsuperscript{rd} Party Matchmakers (Skype, AIM, YIM, MSN)

Network-Layer Connectivity

User

Host

Campus

PSTN

high-performance, end-to-end IP transit

Campus

Internet2/GigaPoP/ASP

Host

User
Emerging Internet2
Real Time Communications Architecture...
Connective Middleware

- **Applications**
  - Alice
  - Bob
- **Connective Middleware**
  - APIs
  - Codecs
  - Signaling
- **Network-Layer Connectivity**
  - Call Routing
    - Presence
    - Identity
  - high-performance, end-to-end IP transit
- **User**
- **Host**
- **Campus**
- **Internet2/GigaPoP/ASP**
- **Campus**
- **Host**
- **User**
Damping Middleware

Applications

Alice

APIs

Codecs

Signaling

Bob

APIs

Codecs

Signaling

Damping Middleware

Connective Middleware

Network-Layer Connectivity

User

Host

Campus

Internet2/GigaPoP/ASP

Campus

Host

User

Auth N/Z

Call Filtering

Call Routing

Presence

Identity

high-performance, end-to-end IP transit
Rich Presence Services

Applications

Rich Presence Services

Damping Middleware

Connective Middleware

Network-Layer Connectivity

User	Host	Campus	Internet2/GigaPoP/ASP	Campus	Host	User

high-performance, end-to-end IP transit

Alice

APIs

Codecs

Signaling

Location

Calendaring

Call Filtering

Auth N/Z

Call Routing

Presence

Identity

Bob

APIs

Codecs

Signaling

Location

Calendaring

Call Filtering

Auth N/Z

Call Routing

Presence

Identity
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Enterprise Directories

- Rich Presence Services
- Damping Middleware
- Connective Middleware
- Network-Layer Connectivity

Applications

Alice

APIs

Codecs

Signaling

Bob

User

Host

Campus

Internet2/GigaPoP/ASP

Campus

Host

User

Directories

- Location
- Calendaring
- ... Auth N/Z
- Call Filtering
- Call Routing
- Presence
- Identity

- Call Routing
- Presence
- Identity
P2P and Inter-Campus Trust

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Your Campus is Here!

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SIP.edu

- **Web Site**
  - [http://voip.internet2.edu/SIP.edu/](http://voip.internet2.edu/SIP.edu/)

- **Project Leader**
  - Dennis Baron, MIT
  - Email, sip: dbaron@mit.edu

- **Organization**
  - Currently a VoIP WG project
  - Evolving as SIP.edu community builds
SIP.edu Charter

**Goals**
- Grow number of SIP connectivity and use
- Increase value of end-user SIP adoption
- Promote converged electronic identity
- Low entry-cost means for campuses to...
  - Provide a useful initial service
  - Start getting their feet wet with SIP

**Means**
- **SIP.edu Cookbook** available on web site
- Partnering with vendors (Cisco, Avaya)
- Building community of implementers (*e.g.* First SIP.edu Implementors Workshop)
Addressing

• Users should not be burdened with device addresses, when it’s people they really care about
• Addresses should be mnemonic and empower enterprises to manage the identities of their users
  – sip:ben@internet2.edu
• It’s time to put E.164 phone numbers behind us!
• A.G. Bell did not say...

“+1-617-637-8562, come here. I need you!”
SIP.edu Architecture (today)

SIP User Agent

DNS SRV query (sip:bob@bigu.edu)
sip.udp.bigu.edu

INVITE
(sip:12345@gw.bigu.edu)

SIP-PBX Gateway

INVITE
(sip:bob@bigu.edu)

DNS
sip.udp.bigu.edu
IN SRV...

SIP Proxy

telephoneNumber where mail="bob"

Campus Directory

IP Voice

PRI / CAS

PBX

bigu.edu

TDM Voice

Bob's Phone

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If Bob has registered, ring his SIP UAs; Else, call his extension through the PBX.
SIP.edu Growth

>8 other schools working on it
Presence and Integrated Communications WG (PIC)

- **Web Site**
  - [http://pic.internet2.edu/](http://pic.internet2.edu/)

- **Chair**
  - Jeremy George, Yale University
    - {email, im, sip}: jeremy.george@yale.edu
Presence and Integrated Communications

• Presence
  • “Notification of events that facilitate communication” (Henning Schulzrinne)
  • Back to the future?
    – Remember: finger, write, who?
    – Presence restores the sense of community that existed on timesharing systems
  • Forward to the future!
    – New standards for interoperability and scalability
    – User-centric control of presence publication
    – Richer state semantics and automatic triggers
Rich Presence Trials

Participant’s WiFi laptop, SIP soft-client (sipc or Session), and headset

Cisco 7960 speakerphone (one placed in each room and joined to an eDial conference)

HP Labs “Skiff” (passive WiFi device used to triangulate laptop signals)
Rich Presence Trials

- Using Internet2 meetings to prototype advanced campus services
  - Advanced WiFi infrastructure (location service)
  - Advanced middleware infrastructure (SIP/SIMPLE presence agent / location server)
  - Advanced real time communications services

- Highly-participatory
  - Enthusiastic attendees
  - Distributed trial-dev team
    - Columbia IRT Lab, HP Labs Cambridge, University of Pennsylvania, Ford Motor Company, Microsoft, ...
WiFi Location Tracking

- HP Labs Metro Project
- Signal Strength Location Tracking
  - Room-level accuracy
  - Sniff client signal strength from multiple monitors
  - Triangulation difficult due to walls, multipath effects
    - Match signal strength signature of target locations
    - Calibrate system by gathering signatures for each location
  - No client software required
    - But clients have to transmit to be located

This slide complements of Jamey Hicks (HP)
“Skiffs”

Standard access points
No client software
“Skiff” monitors

SA110 single board computer running Linux
Report signal strength, MAC address, & IP address of all packets seen

This slide complements of Jamey Hicks (HP)
Client Locations (Map View)

- IP addresses and SIP registry used to map SIP URIs
- Very useful for finding rogue APs too
Determining location

- **End system determines location**
  - “handset-based” (GPS, 802.11, beacons)

- **Network conveys location**
  - MAC backtracking
  - AP-based 802.11 triangulation
  - Swipe cards, iButtons, active badges

- **GPS may not be practical** (cost, power, problems indoors)
IETF efforts

- **GEOPRIV working group**
  - DHCP Option for Civil Addresses
  - A Presence-based GEOPRIV Location Object Format

- **SIMPLE working group**
  - RPID - Rich Presence Information Data Format
  - CIPID: Contact Information in Presence Information Data Format

- **SIPPING working group**
  - Requirements for Session Initiation Protocol Location Conveyance
Rich Presence Enabled Clients

- WaveThree and Columbia clients (Session, SIPC)
- Others welcome! (client requirements doc on web)
## Rich Presence Portal

**ben@internet2.edu in Keoni**

### Quick Links
- Help
- MAC Address Locations
- SIP User Locations

### Rooms
Click on any of the hyper-linked rooms to listen in.

<table>
<thead>
<tr>
<th>Room</th>
<th>Session</th>
<th>Packet Loss</th>
<th>Expected Voice Quality (G.111 MOS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>ECSS meeting</td>
<td>0.00%</td>
<td>Excellent (5)</td>
</tr>
<tr>
<td>East/West Center</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Garden Level</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Ground Floor</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Ground Floor Lobby</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Kamohana</td>
<td>APAN meeting (Backbone Committee)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Kaniula</td>
<td>Extended Astronomy BOF</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Koi</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Makana</td>
<td>NTech In-Depth DNS</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Mandarin</td>
<td>JUAPAN conference war room</td>
<td>0.00%</td>
<td>Excellent (5)</td>
</tr>
<tr>
<td>Okina</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Pacific</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Pago Pago</td>
<td>UN-ITS Office</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Peachanna</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Rahanan</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Seremonok</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Sajong</td>
<td>0.00%</td>
<td>Excellent (5)</td>
<td></td>
</tr>
<tr>
<td>Shizirano</td>
<td>0.00%</td>
<td>Excellent (5)</td>
<td></td>
</tr>
</tbody>
</table>

### People
Click on a SIP URI to initiate a call (works for SFP/Mozilla on Windows).
Users marked "PIC on me!" are staffing a "distributed help desk". Feel free to ask us questions!
Use the controls below to set your location manually or to filter your view of other users' presence.

<table>
<thead>
<tr>
<th>Name &lt;SIP URI&gt;</th>
<th>Online/Offline</th>
<th>Room [Session]</th>
<th>Packet Loss</th>
<th>Expected Voice Quality (G.711 MOS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steven Blair <a href="mailto:sip.blair@ece.virginia.edu">sip.blair@ece.virginia.edu</a></td>
<td>offline</td>
<td>East/West Center</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Heather Spies <a href="mailto:sip.heather@internet2.edu">sip.heather@internet2.edu</a></td>
<td>online</td>
<td>n/a</td>
<td>0.00%</td>
<td>Excellent (5)</td>
</tr>
<tr>
<td>Daniel Ekhud <a href="mailto:sip.daniel.eklund@wayne.edu">sip.daniel.eklund@wayne.edu</a></td>
<td>offline</td>
<td>Keoni</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Arthur Geylord <a href="mailto:sip.angylor@boei.edu">sip.angylor@boei.edu</a></td>
<td>online</td>
<td>Keoni</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Jeremy George <a href="mailto:sip.jeremy.george@vlsi.edu">sip.jeremy.george@vlsi.edu</a></td>
<td>online</td>
<td>Mandarin JUAPAN conference war room</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Russ Hobby <a href="mailto:sip.rdhobby@internet2.edu">sip.rdhobby@internet2.edu</a></td>
<td>offline</td>
<td>Kaniula Extended Astronomy BOF</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Russ Hobby <a href="mailto:sip.rdhobby@internet2.edu">sip.rdhobby@internet2.edu</a></td>
<td>online</td>
<td>Kaniula Extended Astronomy BOF</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Steven McKee <a href="mailto:sip.smckee@umich.edu">sip.smckee@umich.edu</a></td>
<td>offline</td>
<td>East/West Center</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Garrett Yoshimi <a href="mailto:sip.g.yoshimi@hawaii.edu">sip.g.yoshimi@hawaii.edu</a></td>
<td>online</td>
<td>n/a</td>
<td>0.00%</td>
<td>Excellent (5)</td>
</tr>
<tr>
<td>Garrett Yoshimi <a href="mailto:sip.g.yoshimi@hawaii.edu">sip.g.yoshimi@hawaii.edu</a></td>
<td>offline</td>
<td>Keoni</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Jamey Hicks <a href="mailto:sip.jamey.hicks@no.com">sip.jamey.hicks@no.com</a></td>
<td>online</td>
<td>Mandarin JUAPAN conference war room</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

These results are incomplete because we are having trouble ARPing through some APs.
Please stand by.

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**Connective – EDUCAN 2004 – Denver, CO**
Rich Presence Trials

- **Arlington, April 2004**
  - **Venue:** Spring 2004 Internet2 Member Meeting, Arlington, VA
  - **Presence Elements:** location (automatic); room session name; session end time; per-room internet weather

- **Honolulu, January 2004**
  - **Venue:** Winter 2004 Joint Techs Workshop, University of Hawaii
  - **Presence Elements:** location (automatic); room session name; session end time; per-room internet weather
  - **Clients:** sipc (Windows, Linux); presence portal

- **Indianapolis, October 2003**
  - **Venue:** Fall 2003 Internet2 Member Meeting, Indianapolis, IN
  - **Presence Elements:** location (manual); room session name; session end time;
  - **Clients:** sipc (Windows, Linux); Session (Mac, Windows); presence portal
Internet 911 (I911)
- 911 has been a thorn in the side of VoIP
- Technically, not a hard problem

NTIA I911 project to IP-enable PSAPs

Not only solve 911 for VoIP, but do better
- Higher resilience
- Faster call setup
- Testability
- Multimedia support
- Open standards and COTS
- Cheaper

Based on IETF GEOPRIV work
Emerging IETF/NENA “I3” Architecture

Location-based call routing: UA knows its location

- GPS
- INVITE sips:sos@
- 40.86N 73.98E CN=us A1=NJ A2=Bergen
- outbound proxy server
- provided by local ISP?
- DHCP
- 40.86N 73.98E: Leonia, NJ fire dept.
- leonia.nj.us.sos.arpa
- POLY 40.85 73.97 40.86 73.99
- NAPTR ...
- firedept@leoniaboro.org

This slide complements of Henning Schulzrinne, Xiaotao Wu, & the CINEMA crew (Columbia University)