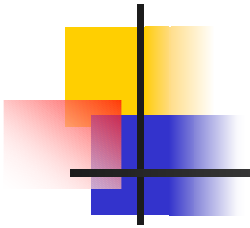
NIST
National Institute of Standards and Technology

INFORMATION TECHNOLOGY LABORATORY



NIST Distributed Testbed for First Responders

BFRL, EEEL, ITL, and MEL
NIST

June 10, 2003

Problem

- 9/11 terrorist attacks brought to forefront a major deficiency of first responder communication systems:
  - First responders use a multitude of radio systems that do not interoperate ……
- This hinders first responder operations.
- Federal government is committed to change this situation.

Possible Solutions

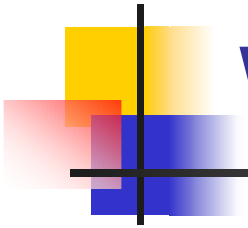
- Short Term – Improve interoperability of radio equipment in use today through
  - Frequency spectrum coordination
  - Minor hardware / software fixes in radios
- Long Term – Develop standards for highly capable, next generation first responder communication equipment and over time replace existing radios.

NIST Plan

- Develop a testbed incorporating various modern first responder technologies that goes far beyond solving the communication problem by offering a complete solution package and dramatically improved capabilities for future first responder systems.
- The testbed could serve as the nucleus for standards for next generation of first responder systems.

"Complete Solution"

- Integrated Communications (voice/data/video)
- Sensor Networks
- Geolocalization and tracking of assets / threats
- Fire growth models
- Building integrity models (VCBT)
- Command and control, authentication and security
- Human computer interactions and remote collaborations
- Various GUI and data format standards



Why NIST?

…… our long track record in facilitating development of national / international standards through research, testing, and measurements.

Networking Technologies for Next Generation First Responder Systems

Principal Components & Expectations

	Present	Future
First Responder Communications	push-to-talk radios	unicast / multicast / broadcast capabilities
	voice only	text / voice / video / sensor data
	severe interoperability problems	interoperable through new standardization
	fixed infrastructure	ad hoc network

Networking Technologies for Next Generation First Responder Systems

Principal Components & Expectations (Cont'd)

	Present	Future
Sensor Deployment	Stand alone heat / smoke sensors	multi-modal sensory capability with data fusion; possibly interoperable with first responder communication equipment
Geolocalization	GPS available outdoors; no indoor solutions	3-D localization

Network Architecture: Wireless Ad Hoc Networks

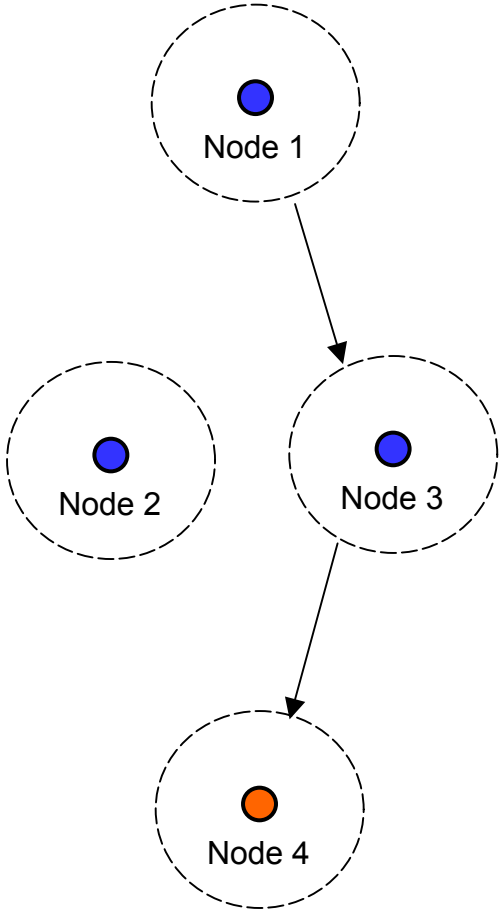
- Infrastructureless (no base stations or access points)
- Self-organized
- Adaptable to varying topology and traffic conditions
- Robust: Degrades gracefully in face of node / link failures and local congestion
- Efficient (bandwidth, power consumption, user capacity) through multihop communications & spatial reuse
- Possibility of QoS provision
- Scalable

Testbed Hardware

- Compaq iPAQs running Linux.
- Linux provides a seamless development platform, access to low level network functions and a large community of active researchers.
- Dual PCMCIA card backpack with battery.
- Low-power Strong-ARM chip, 2800mA battery capacity, ~8 hour runtime using 802.11b card.
- 10 iPAQs have Bluetooth, allowing for wireless headsets, sensors, GPS, and more!
- Full-duplex audio, with headphone jacks.

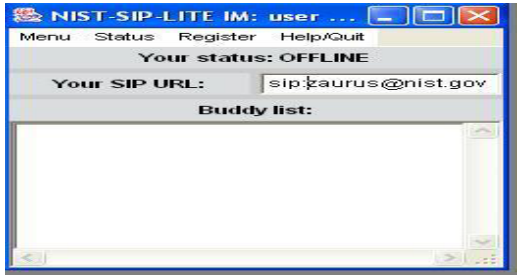
Current Capabilities

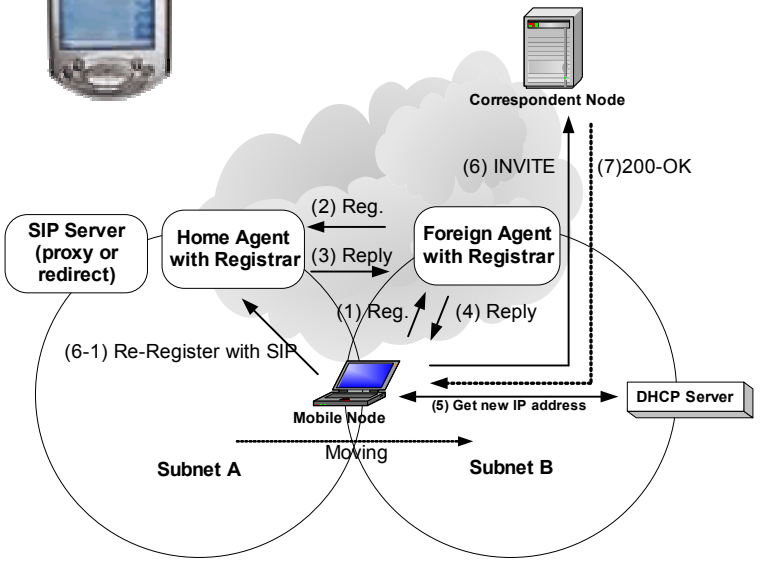
- Broadcast communications
- Private communications
- Functions over multiple hops
  - Dramatically increases range
  - Devices in between serve as relays
  - Increases traffic carrying capacity
- Able to collect and monitor data from each device
  - Location
  - Sensor information



SIP in Mobile / Ad hoc Networks

- **Expedite development of SIP signaling in mobile ad hoc networks.**
  - Evaluate JAIN/SIP on constrained wireless platforms.
  - Investigation the integration of SIP with other mobility protocols, ad hoc routing protocols, and location awareness technologies.
  - SIP signaling extensions for presence, messaging, 3rd party call control.
- Ongoing Research:
  - Incorporating **NIST-SIP-LITE** in NIST 1st responders testbed. Designing integration of SIP with AoDV and ad hoc location detection schemes.
  - Micro / macro mobility support for nomadic roaming within and among facilities
  - QoS, hand-off management, security / access control





NIST Goals

- **Goal:** Identify and help remove *technical barriers* to the development of standards based technologies that enable multi-modal communication, information access, and distributed computing capabilities to 1st responders employing wireless / portable information devices.
  - Focus on nomadic emergency response personnel and their movement within ad hoc networks at emergency sites, between facilities and at their stations.
  - Standards based approach to seamless / common communication technology in each scenario and interoperation with civilian communication infrastructures.

Motivations – New Capabilities

- New Modes / Capabilities – Beyond the cordless phone / wireless PDA / Walkie-Talkie.
  - Ubiquitous integrated voice, video, messaging, and distributed computing.
  - **Context Aware** – capabilities responsive to user's presence and location within a facility / transit.
    - **How you are communicated with changes based upon identity/role of caller/callee, where you are, who you are with.**

```
If ((at ENGINE) and (on CALL)) then
   If ((caller!=COMMANDER) or (priority!=URGENT)) then
      divert to voice mail and vibrate
   Else
      ring and answer
```

New Capabilities

- New modes …
  - **Location / Mobility Insensitive** – how caller attempts to communicate with you independent of where you are (hospital, station, en-route, foreign station)
    - `sip:dougm@engine-3.rockville.md.us / 301-555-1234`
  - **Augmenting Limited Devices** – device / user capabilities and preferences can be communicated and supporting devices in the fixed infrastructure discovered exploited
    - **Divert media streams (e.g., hi-res images) from PDA to flat panel bolted to the wall.**
  - **Micro / Macro Mobility –** established sessions continue to operate as I move across network infrastructures
    - **Home – cable modem** **Car – cellular wireless (GPRS, UMTS)**
    - **Starbucks – WLAN** **Clinic – DSL**
    - **Car – Cellular** **Hospital 1st Floor, 3rd Floor - WLANs**

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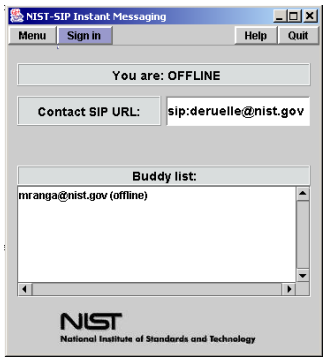
NISTSIP: Integration of SIP Technologies in Adhoc / 1st Responders Networks

NISTSIP Proxy, Registrar, Presence Server

NISTSIP Lite J2ME IM Client



NIST-SIP

POTS

Cell phone

PSTN

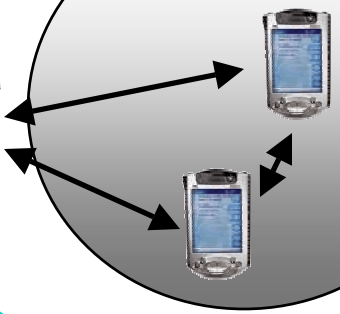
Cellular

Cisco gateway

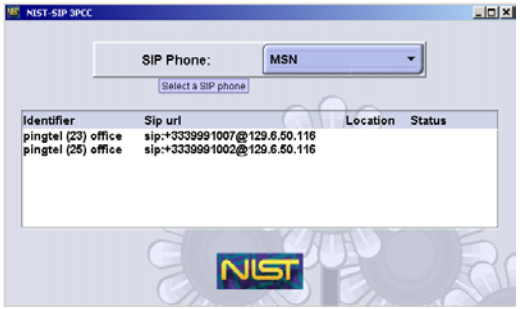
NIST-SIP Proxy / Presence Server

Ad-Hoc Network 1st Responders

Ipaq



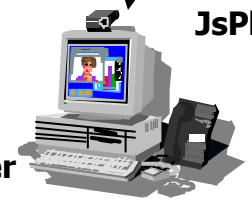
3rd Party Call Control Application



Internet

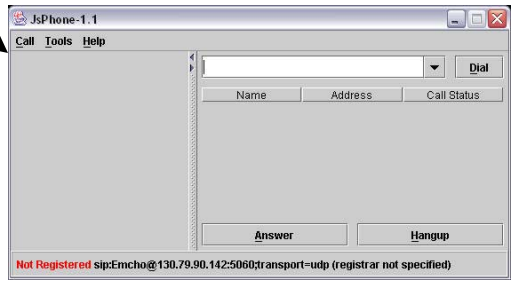
Pingtel SIP Phone

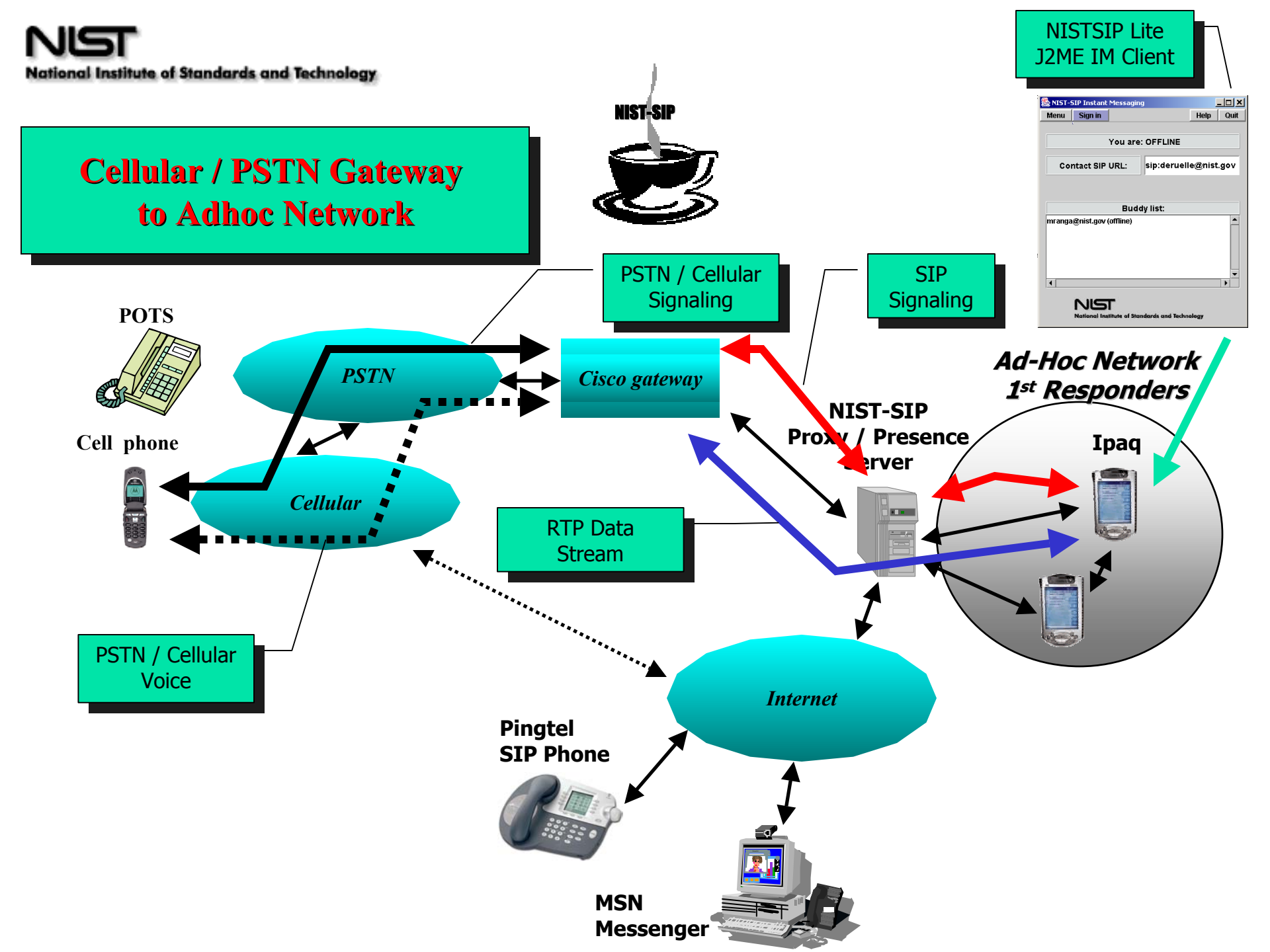
MSN Messenger



JsPhone

NISTSIP / JAIN Soft Phone

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NISTSIP Lite
J2ME IM Client
NIST-SIP Instant Messaging
Menu
Sign in
Help
Quit
You are: OFFLINE
Contact SIP URL:
sip:deruelle@nist.gov
Buddy list:
mranga@nist.gov (offline)
NIST
National Institute of Standards and Technology
Cellular / PSTN Gateway
to Adhoc Network
NIST-SIP
PSTN / Cellular
Signaling
SIP
Signaling
POTS
PSTN
Cisco gateway
Ad-Hoc Network
1st Responders
NIST-SIP
Proxy / Presence
Server
Ipaq
Cell phone
Cellular
RTP Data
Stream
PSTN / Cellular
Voice
Internet
Pingtel
SIP Phone
MSN
Messenger

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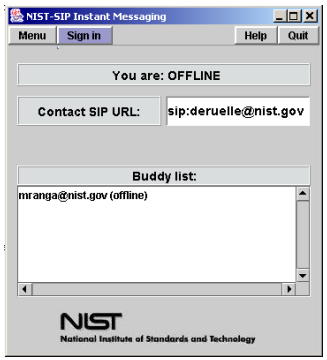
3rd Party Call Control: Application Initiated Call into Adhoc Network.

NIST-SIP

NISTSIP Lite
J2ME IM Client



POTS

Cell phone

PSTN

Cisco gateway

Cellular

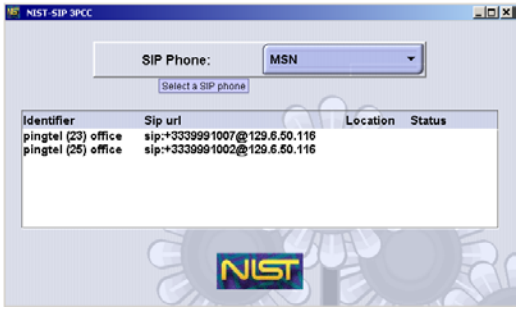
SIP Signaling

NIST-SIP
Proxy / Presence
Server

Ad-Hoc Network
1st Responders

Ipaq

3rd Party Call
Control Application



Internet

Pingtel
SIP Phone

RTP Media Stream

MSN
Messenger

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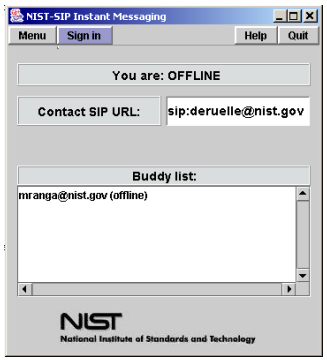
Enabling Integration of Computer Messaging Platforms Into Adhoc Networks

NISTSIP Lite
J2ME IM Client



NIST-SIP

POTS

Cell phone

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NIST-SIP
Proxy / Presence
Server

Ad-Hoc Network
1st Responders

Ipaq

SIP Signaling

Internet

Pingtel
SIP Phone

MSN
Messenger

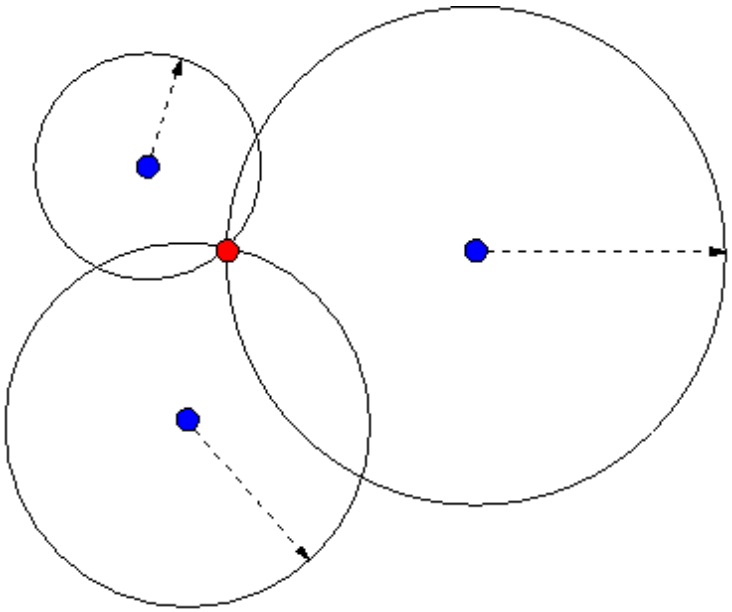
RTP Media Stream

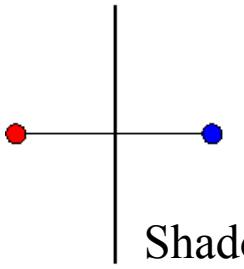
Localization Using Signal Strengths

Triangulation:

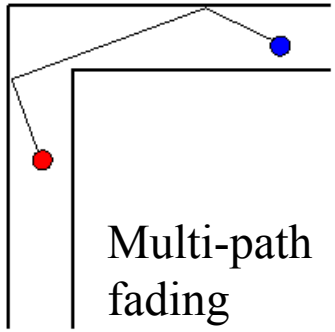
- Determine mobile position through signal strengths from three fixed nodes.
- Works well for: indoors using UWB, outdoors using GPS.
- Difficulties: Uncertainty of power exponent r due to shadowing, multi-path fading, and interference.

$$\text{distance} = \frac{1}{\sqrt[r]{\text{strength}}}$$



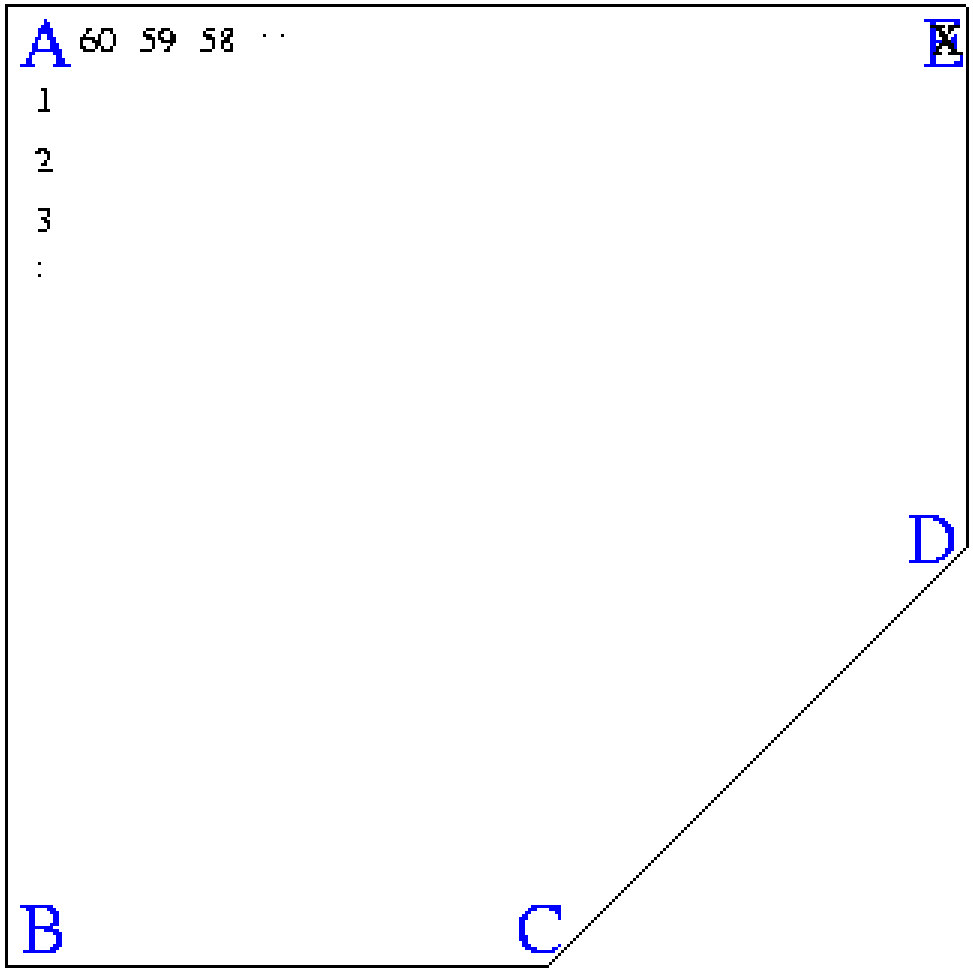


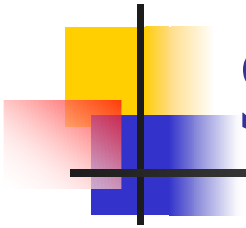
Shadowing



Multi-path fading

Pre-Training Technique





Signal Processing

- Motion model
  - Linear prediction
  - Condensation algorithm
  - Tracks
- Adjacency constraints
- Markov localization
  - Generalized Kalman filtering
  - Incorporates constraints

Video Streaming

- ITU-T H.263++
  - Intended for Very low rate video teleconferencing applications
- H.26L joint MPEG/JVT coding standard
  - Emerging standard strongly poised to lead to a unified solution to video coding
  - Based on conceptual separation between a video coding layer and a network abstraction layer
  - Aimed at providing a "network-friendly" packet-based video representation

Multimedia Communications Tools

- Videoconferencing tool (VIC: UCL)
  - RTP/UDP/IP
    - **JPEG, H.261, H.263+**
  - http://www-mice.cs.ucl.ac.uk/multimedia/software/vic/
- Robust Audio Tool (RAT: UCL)
  - RTP/UDP/IP
  - http://www-mice.cs.ucl.ac.uk/multimedia/software/rat/

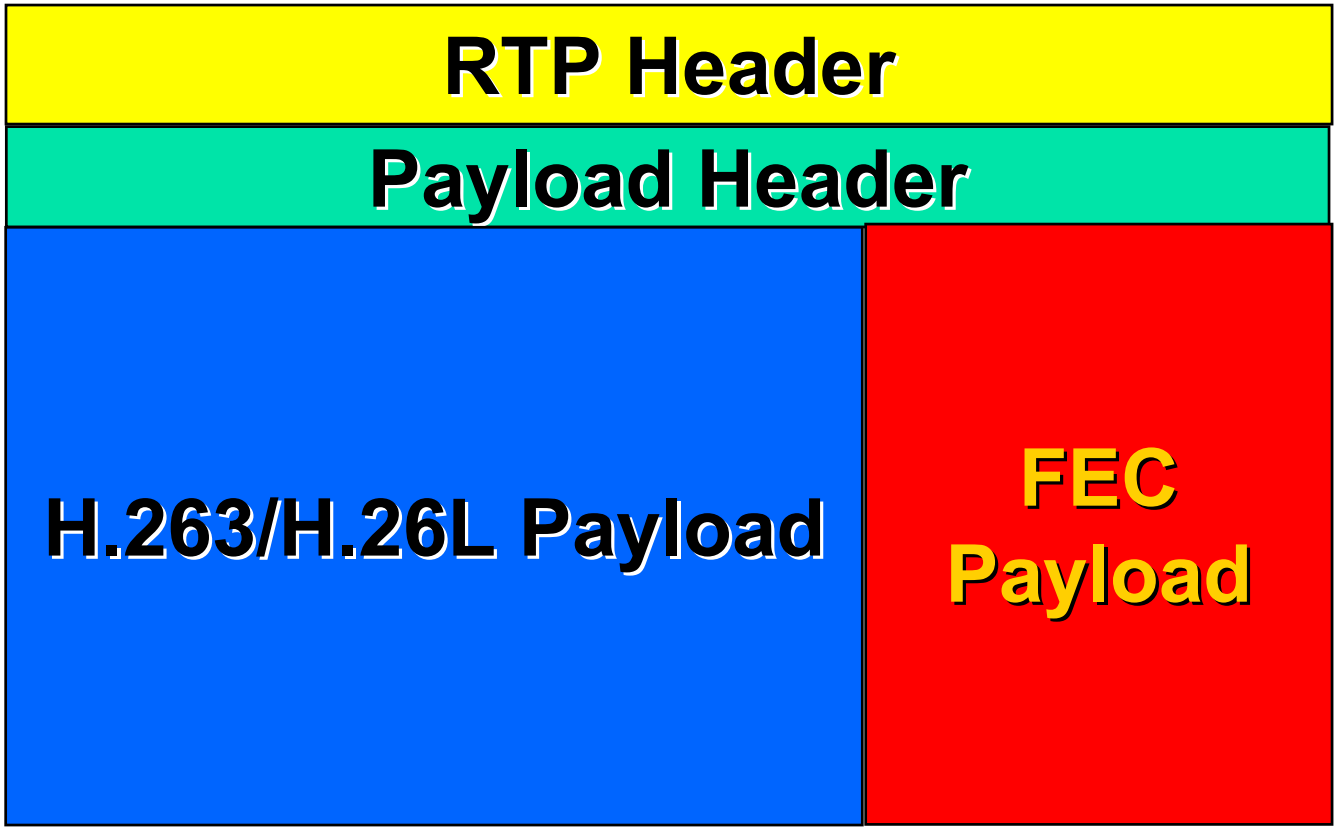
H.263++ Video Streaming

- Payload header format
- Extra picture header
- Error resilient decoding
- Forward Error Correction (FEC) coding
- Encapsulation

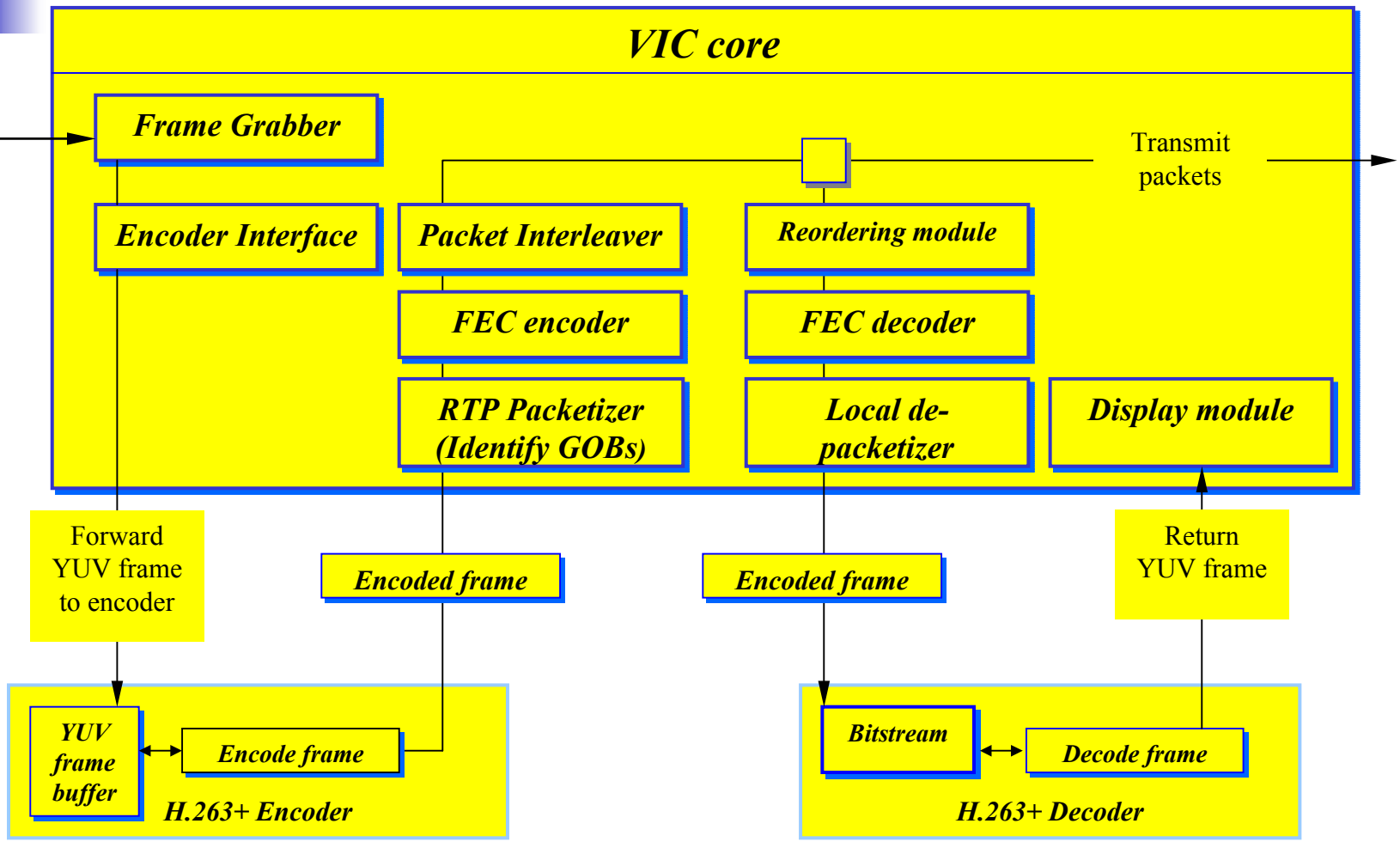
H.26L Video Streaming

- RTP/UDP implementation
- Encapsulation
  - Slice structure
- VIC enhancements
  - Imported H.26L
  - Changed VIC's architecture for flexible encapsulation
  - Improved video processing speed

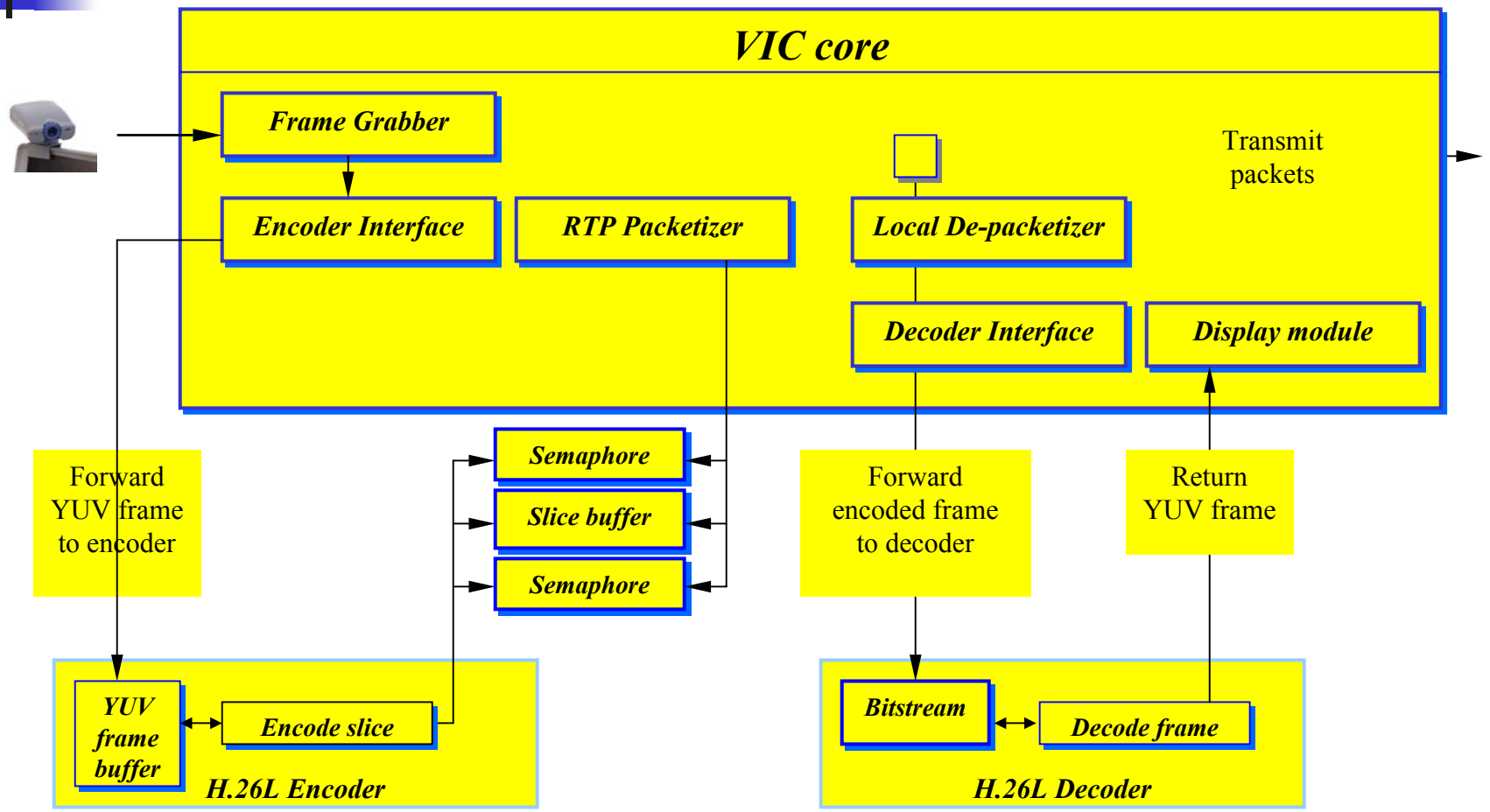
Combined Video/FEC RTP Streaming



VIC GOB-by-GOB



VIC H.26L

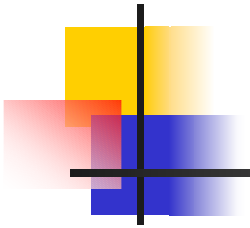

VIC core
Frame Grabber
Encoder Interface
RTP Packetizer
Local De-packetizer
Transmit packets
Decoder Interface
Display module
Forward YUV frame to encoder
Semaphore
Slice buffer
Semaphore
Forward encoded frame to decoder
Return YUV frame
YUV frame buffer
Encode slice
H.26L Encoder
Bitstream
Decode frame
H.26L Decoder

H.26L Video Demo

- Transmission via WLAN

Conclusions

- We have only scratched the surface, and there is much more to be done!
- NIST with its diverse competencies and its established relationships with industry, academia, first responder user community, and state / federal government agencies is well positioned to make a major impact in this area.



Backup Slides … on SIP etc

NIST-SIP:

Improving the Quality and Expanding the Scope of Next Generation Internet Telephony Signaling.

- **Project Contacts**:
  - M. Ranganathan (mranga@nist.gov)
  - Doug Montgomery (dougm@nist.gov)
- **Participants**:
  - Olivier Deruelle, Jin Woo Jung, Jean Deruelle
- **Sponsors**:
  - ATP – Electronic Commerce Program.
  - DARPA – Active Networks Program.
- **Collaborators**
  - Java Community – SIP, SIP-Lite, Servlets, SIMPL.
  - Sun/MS, Lockheed Martin, Terminal Technologies, Lucent, Open Cloud, Worldcom, Panasonic, Nortel, Alcatel, Blue Labs, Key Voice, IBM Zurich, Florida State U, Darmstad U ….

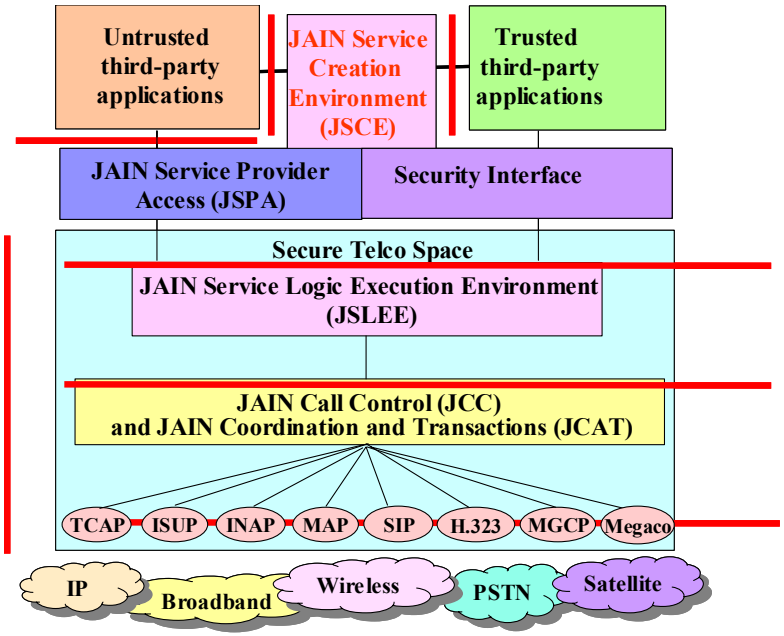
Why is NIST Involved & How?

- **Improving Quality of IP Telephony(+) Technology**
  - **SIP research & development & testing**
    - **NIST-SIP research platform**
    - **SIP-WIT test system**
- **Expanding Scope of Application for SIP Technology**
  - **Programmable SIP Networks**
    - **Open API's / platforms for 3rd party applications**
      - Java JAIN/SIP, SIP XML
    - **Dynamic service creation**
      - PASS Project, JAIN/Servlets, JAIN/SLEE
  - **Nomadic / Pervasive Computing & Emergency Response**
    - **SIP in information appliances & embedded computing**
      - NIST-SIP-Lite research platform - JAIN/J2ME.
    - **SIP for nomadic communication, monitoring & control applications.**

JAVA API's in INTELLIGENT NETWORKS (JAIN)

Goal: Enable open, soft switch, platforms for network / telecom

- JAIN enables for application portability across protocol stacks & platforms.
- JAIN/SIP – JAVA standard API to a SIP Signaling Stack.
  - Wraps the low-level stack and protocol abstractions in a JAVA interface layer
- Allows a JAVA application, servlet or bean to imbed a SIP stack and access low level functions.

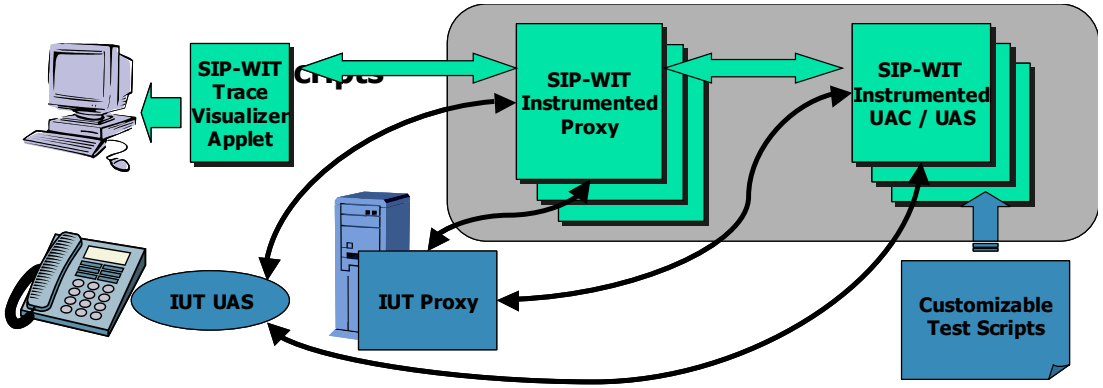


NIST-SIP and JAIN/SIP

- NIST-SIP 1.2 Research Platform
  - Antlr-based Java message parser with flexible error handling and extensibility.
  - SIP Stack with authentication support.
  - JAIN-SIP 1.0 certified compliant interfaces.
  - JAIN-SIP proxy
  - JAIN Instant Messaging tool (interoperates with Microsoft IM).
  - Interop Tested at SIPIT 11 in Atlanta GA.
  - Over 5000 downloads.
- JAIN/SIP 1.1
  - Collaborative effort with SUN Microsystems on API/ Stack design.
  - New JAIN/SIP design is closely based on the NIST-SIP architecture.
  - API is fully re-designed to align with RFC 3261.
  - Supports IM and presence and has extensibility features for future SIP extensions.
  - RI and TCK from NIST

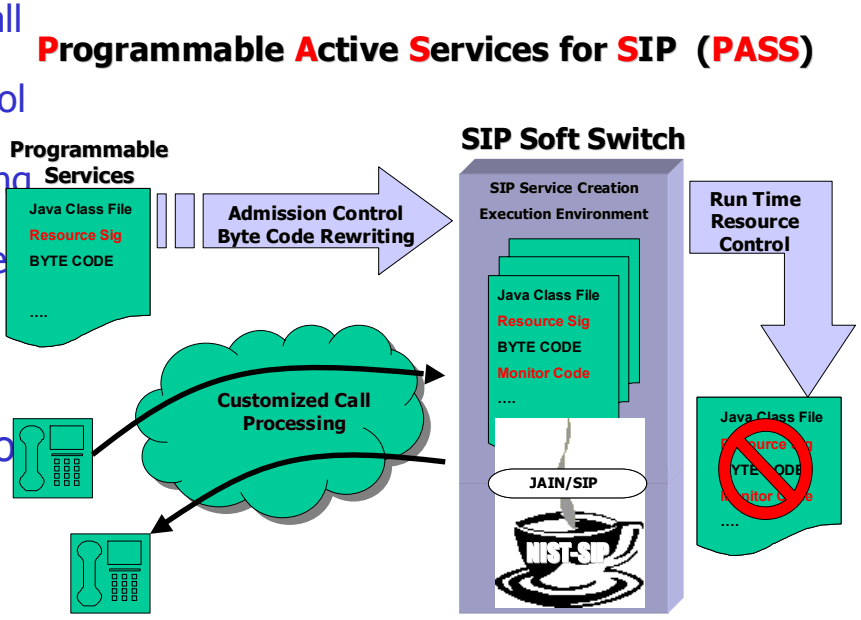
NIST-SIP WIT

- **W**eb-based **I**nteroperability **T**ester
  - Enable WWW-based remote, multiparty testing against signaling templates. User defined tests.
  - Instrumented test system, with logging, diagnostics and call flow visualizations.
- SIP-WIT - http://www-x.antd.nist.gov/sip-wit
  - Since July 2002 ~100 organizations ran ~700 test sessions.
  - Ongoing Research:
    - **User up-loadable**



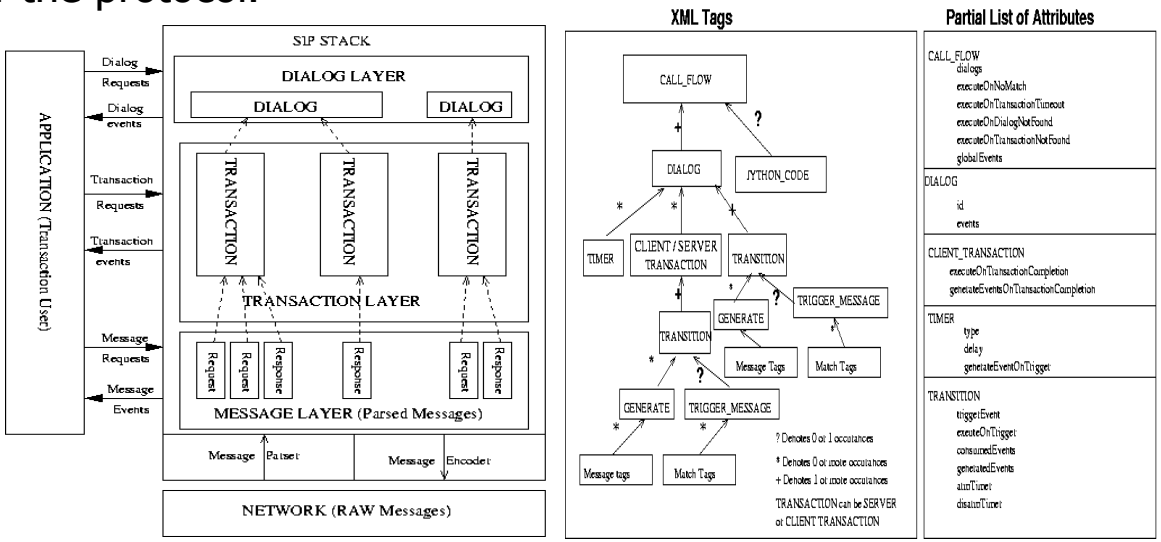
Programmable SIP Services

- Programmable Active Services for SIP (PASS)
  - Enable user injection of fully general call SIP processing code.
  - Resource estimation and admission control for service scripts.
  - Use bytecode re-writing technique for uploading SIP Service scripts.
  - Resource monitoring framework for service creation environments.
  - Domains of applicability
    - **Up-loadable test scripts for test system.**
    - **Up-loadable SIP Servlets.**
  - Incorporate into emerging service creation frameworks / standards.



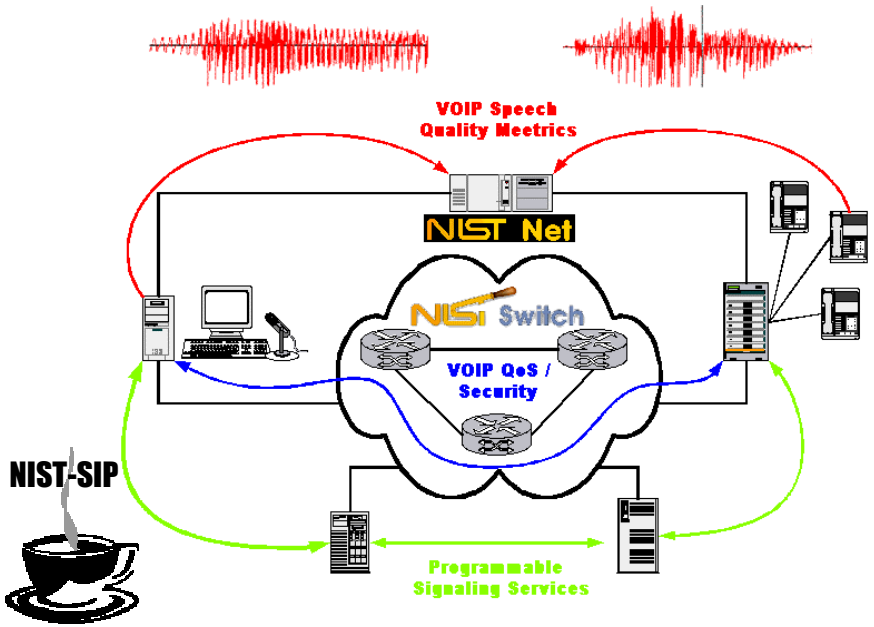
Programmable SIP Clients

- SIP-XML : XML Templates for Scripting SIP Call Flows
  - Enable on-line deployment of new SIP client applications / extensions.
  - Define a set of XML tags and attributes that can describe the behavior of a SIP Call Flow from the perspective of a UA.
  - XML is input to a customizable user agent that generates and executes a state machine from the description.
  - User can specify code that gets invoked at protocol state transitions during the operation of the protocol.
- Technology Evolution
  - Based on SIP-WIT
  - Scripted clients
  - Diagnostics / logging



Short-Term Impact

Internet Telephony / Voice over IP



Goals

To facilitate the development of improved VoIP transport mechanisms and expedite the development of new, programmable telephony signaling services.

Technical Approach

- Research approaches to resource control for emerging Internet telephony service creation architectures.
- Research the application of Internet Telephony signaling protocols to presence / location tracking and device control in pervasive computing environments.
- Deliver rapid prototypes and test and instrumentation tools to the IP telephony industry.

Customers

- 1000's of IP telephony researchers and developers.

Collaborators

- Java/JAIN community
- Sun/MS, Lockheed Martin, Terminal Technologies, Lucent, Open Cloud

FY03 Plans

- Complete JAIN/SIP specifications, reference implementations and test systems.
- Design and evaluate techniques for resource control in fully programmable service creation environments.
- Design and evaluate techniques for dynamically scripting SIP agents behavior.
- Design and evaluate SIP extensions to accommodate micro-mobility protocols and ad-hoc networks.
- Explore the application of SIP technologies in wireless / ad-hoc networks for 1st responders and health care providers.

Publications / Stds Contributions / Talks:

- M. Ranganathan, P. O'Dohery (SunMS), *Java Technology for Internet Communcations,* JavaOne 2003.
- M. Ranganathan, O. Deruelle and D. Montgomery, *Testing SIP using Protocol Templates*, Testcomm 2003.
- M. Ranganathan, *Implementing JAIN SIP*; Invited Talk - SIP Summit 2002. Las Vegas NV. May 2002.
- M. Ranganathan, D. Montgomery, K. Mills; *Resource Management and Containment for Active Services*; DARPA Anets PI meeting; December 2001.
- M. Ranganathan; *A WWW-based Tool for SIP Interoperability Testing;* Cisco RTP NC; April 2001.

- Java/JAIN Community – Standards/Tools Leadership:
  - **JAIN/SIP** **Spec Lead** **NIST-SIP RI**
  - **JAIN/SIP-LITE Expert Group** **NIST-SIP RI**
  - **JAIN/Servlets** **Expert Group** **NIST-SIP RI – Sun MS**
  - **SIMPL** **NIST-SIP RI – Panasonic Research**

Tools:

- NIST-SIP: Java/JAIN compliant SIP prototype reference implementation and parser generator.
  - **http://www.antd.nist.gov/proj/iptel/ - over 5000 downloads since June 2001.**
- SIP-WIT: WWW-based SIP Interoperability Test System.
  - **http://www-x.antd.nist.gov/sip-wit/ - over 500 test sessions from 100 organizations.**

Example Feedback form SIP Industry

Dear Ranga and Doug,

I downloaded a week ago your JAIN-SIP-Stack implementation.

I just want by this e-mail to tell you that you did a great job! Congratulations! It is a huge and well done effort. It is a tremendous scientific contribution.

I will explore in more details your packages and I might be back to you with some questions.

Again Bravo!

Kind regards,

Mourad.

Dr. Mourad DEBBABI
Lead Scientist
Panasonic Information & Networking Technologies Laboratory,
Two Research Way,
Princeton, New Jersey 08540.
E-Mail: debbabim@research.panasonic.com

Subject: CONGRATULATIONS !!!!!
Date: Fri, 10 May 2002 16:59:15 -0700
From: Margaret Nilson <margaret.nilson@sun.com>
Organization: Sun Microsystems

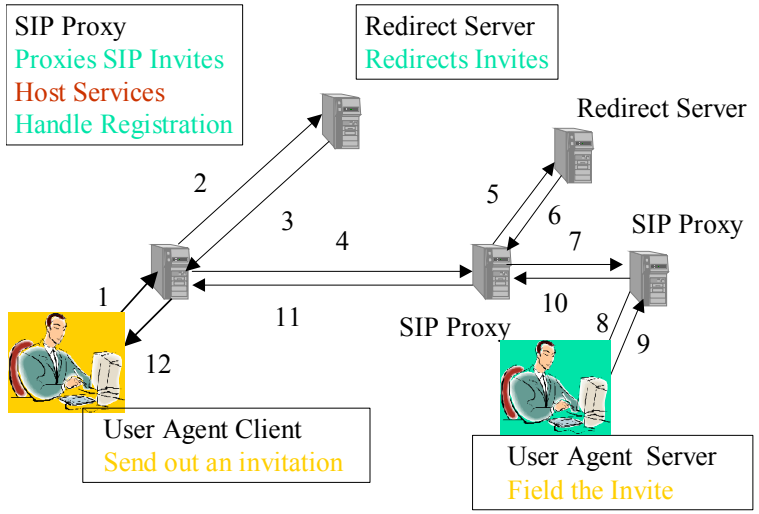
Dear Ranga, Doug, and David,

Wonderful job in achieving your JAIN SIP Certification !!! We'll be sure to feature you in the next issue of the JAIN Community Newsletter , as well as list your product as fully certified on the JAIN website. Thank you for your continued support of the JAIN program.

Best wishes,
Margaret Nilson
JAIN Program Manager

What is this "SIP"?

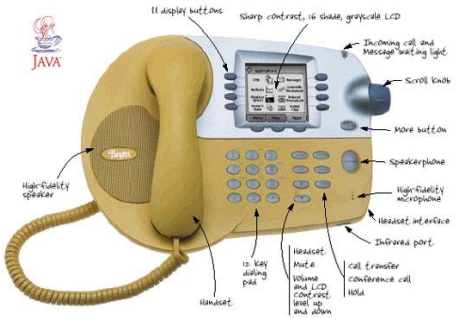
- Session Initiation Protocol - HTTP-like signaling protocol to setup and manage "media sessions" (phone call, IM, video, games).
  - Loosely coupled architecture of clients, proxy servers that leverage DNS and URI's to allow "users" to register their availability and be found anywhere on the net: sip:mranga@nist.gov.
  - Distributed call processing allows intelligence in the clients and distributed intelligence in the network.
  - SIP is designed to be extensible at both the protocol and call processing level. Enabling technology for new media services.



- OK, what is all the excitement about?

SIP as a Disruptive Technology

- Integration of Telephony / Internet
  - SIP's basis in Internet technologies such as HTTP, DNS, URI's, and MIME enables seamless integration of voice, messaging, presence, instant messaging with WWW and other Internet services.
  - SIP enables seamless integration of traditional PSTN telephony with new internet based services.
- New markets for equipment and services
  - SIP's distributed call processing model combined extensibility / programmability enable markets / business models for media applications.
  - SIP is media/use agnostic. Establish "sessions" for any pu internet games, control appliances, etc.
  - Future SIP-enabled devices (e.g., cell phones) will exploit the technology in many more ways (e.g., networked appliance control)
- Ok, Who is interested by all of this?



Who is Interested and Why?

- Platform Vendors:
  - Phones, PCs, soft switches
- Service Vendors:
  - Call centers, centrex, messaging
- Service Providers:
  - ISPs, PSTN & Wireless Carriers
- Industry groups: