

# Automated Testing of a Converged Conferencing Application

Venkita Subramonian, Eric Cheung, Gerald Karam  
AT&T Labs – Research

May 19, 2009

Workshop on Automation of Software Test, ICSE 2009

Thanks to Gregory Bond, Thomas Smith, Hal Purdy and Pamela Zave

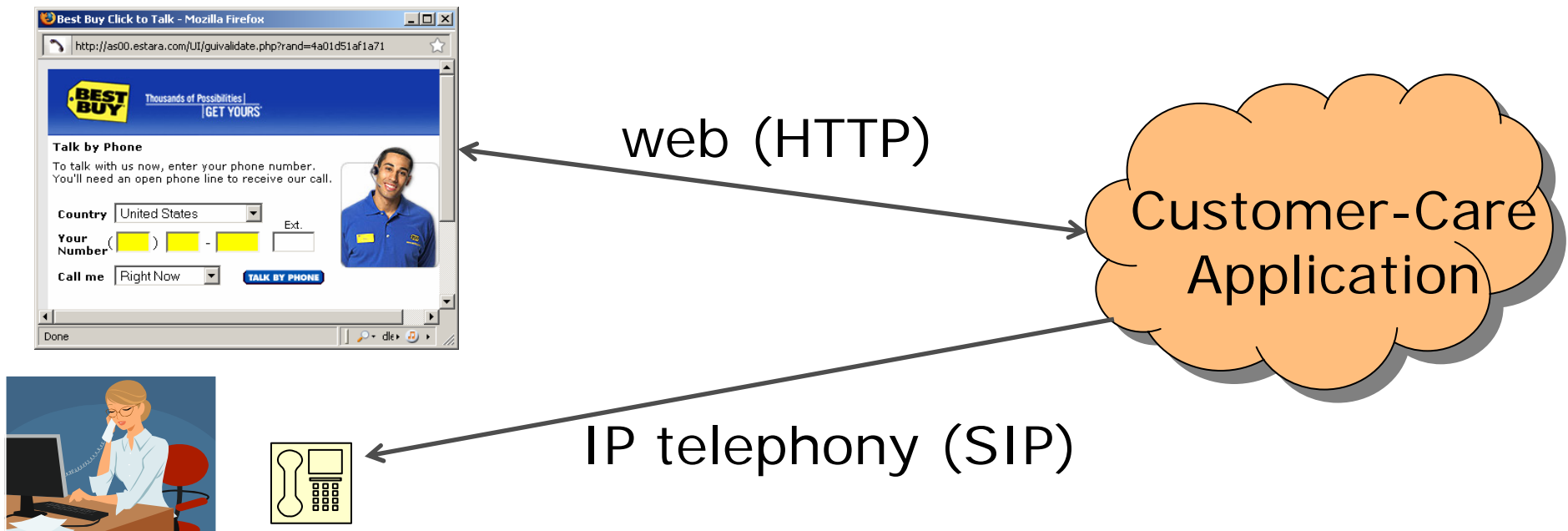


# Converged Telecom Applications

Focus of this talk – automated functional testing of converged telecom applications using open-source software

Converged applications use multiple interfaces and protocols

IP telephony is a key part of converged telecom applications



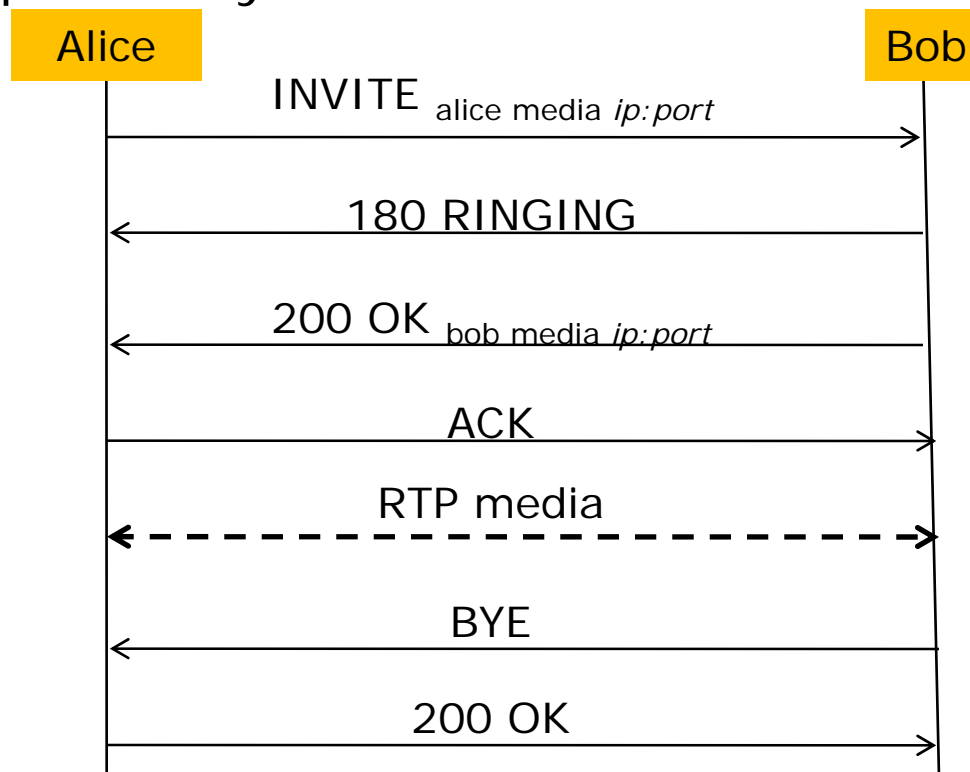
# Session Initiation Protocol (SIP)

Signaling protocol to establish media session between endpoints

IETF RFC 3261

Protocol message structure similar to HTTP

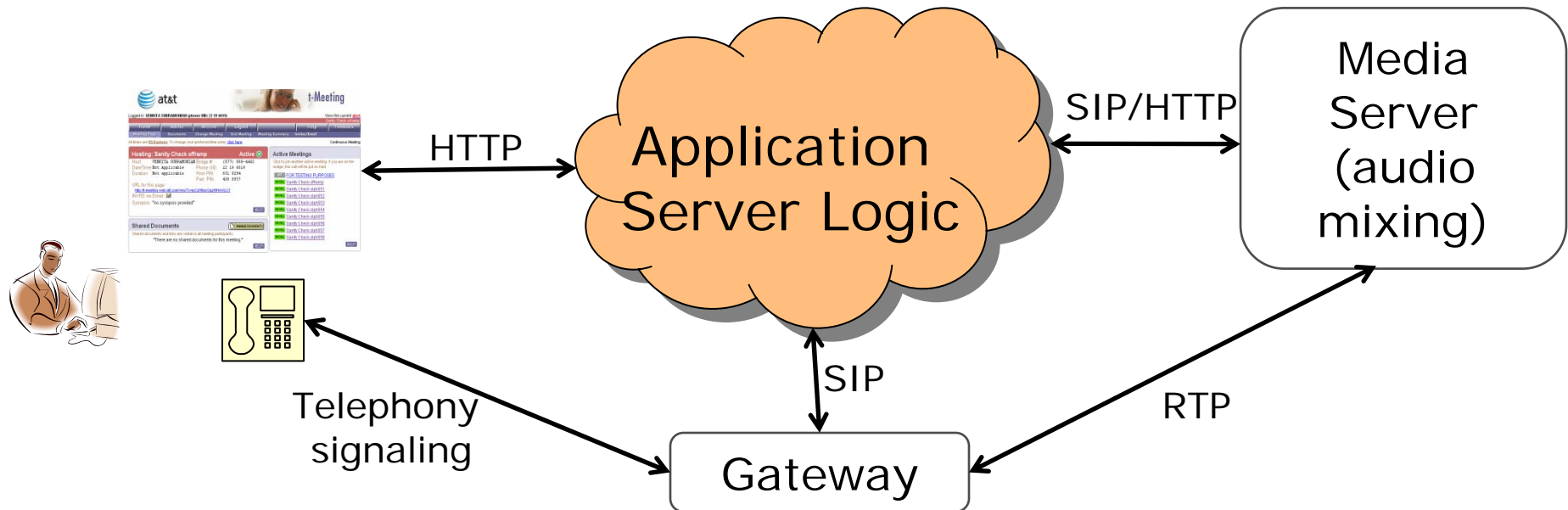
SIP endpoint may act as a client or a server



# Motivating Example – t-Meeting

Internal teleconferencing application



10000 simultaneous calls, millions of call minutes per workday



t-Meeting v1.1.1D: SUBRAMONIAN: May 9, 4:07 PM EDT - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://golf.research.att.com:7580/vms/Updat

Logged In: VENKITA SUBRAMONIAN (phone UID: 22 19 6019)

SUBRAMONIAN: May 9, 4:07 PM EDT

Home Admin Archive Logout Meeting Summary Invites/Email  
 Meeting Page Documents Change Meeting End Meeting Help Feedback

All times are [UTC/Edison](#). To change your preferred time zone, [click here](#). Ad Hoc Meeting

**Hosting: SUBRAMONIAN: May 9, 4:07 PM EDT** Active

Host: VENKITA SUBRAMONIAN [UPDATE HOSTING](#)

Host: VENKITA SUBRAMONIAN Bridge #: (800) [REDACTED]  
 Date/Time: Not Applicable Phone UID: 22 19 6019  
 Duration: Not applicable Host PIN: 349 0007  
 Part. PIN: 997 1436

URL for this page:  
<http://golf.research.att.com:7580/vms/?o=Qu+VMIKq>IDpTYyK?>  
 INVITE via Email: [✉](#)  
 Synopsis: \*no synopsis provided\*

[HELP!](#)

**Shared Documents** [MANAGE DOCUMENTS](#)

Shared documents and links are visible to all meeting participants.  
 \*There are no shared documents for this meeting.\*

[HELP!](#)

**Private Notes & Documents**

Private notes and documents are visible only to you.

[MANAGE DOCUMENTS](#)

Documents  
 \*There are no private documents\*

[EDIT MY NOTES](#)

Notes  
 \*There are no private notes\*

[HELP!](#)

**Meeting Recordings**

\*No recordings are available\*

[HELP!](#)

**Active Meetings**

Click to join another active meeting. If you are on the bridge, this call will be put on hold.

OFF [SallyCleck@12213160...](#)  
 OFF [SUBRAMONIAN: May 9, 4...](#)

[HELP!](#)

**Call Control & Record** [JOIN](#)

HOST PIN: 349 0007  
 -- you are not on the call --

**Host controls**

Conference Recorder

[HELP!](#)

**Participant List** [REMOVE](#) [SPLIT](#)

Speaking:

All participants:  mute-all  unmute-all  
 Mute  Block  On

VENKITA SUBRAMONIAN   OFF

— Que etc —  
 current speaker(s) shown in red

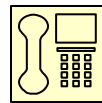
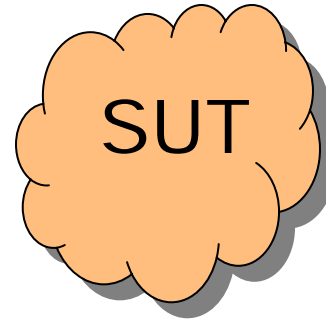
[HELP!](#)

Having problems? Contact [your help desk](#).

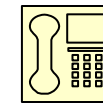
© 2007, 2008 AT&T Intellectual Property. All rights reserved.

Done

# Example Functional Test



Host



Participant



Tester plays 2 roles each with 2 interfaces

# Example Functional Test



Host Browser:  
Login

Participant Browser:  
Login

Cookies an issue



# Example Functional Test



Host Browser:  
Create meeting  
Extract bridge # and host PIN

t-Meeting v1.1.1D: SUBRAMONIAN: May 9, 4:07 PM EDT - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://golf.research.att.com:7580/vms/Upda

at&t t-Meeting

Logged in: VENKITA SUBRAMONIAN (phone UID: 22 18 8018)

Home Admin Archive Logout Meeting page Documents Change Meeting End Meeting Meeting Summary Invites/Email

All times are [JTB/Edison](#). To change your preferred time zone, [click here](#).

Ad Hoc Meeting

Hosting: SUBRAMONIAN: May 9, 4:07 PM EDT Active

Host: VENKITA SUBRAMONIAN UPDATE HOSTING

Host: VENKITA SUBRAMONIAN Bridge #: (800) 425-8976

Date/Time: Not applicable Phone UID: 22 18 8018

Duration: Not applicable Host PIN: 349 0007

Part. PIN: 000 0100

URL for this page:  
[http://golf.research.att.com:7580/vms/70-QuaVMIkpdMCPYY10?](http://golf.research.att.com:7580/vms/70-QuaVMIkpdMCPYY10?INVITE via Email:)  
INVITE via Email:

Synopsis: "no synopsis provided"

Active Meetings

Click to join another active meeting. If you are on the bridge, this call will be put on hold.

See My Call Log (2213168)

SUBRAMONIAN: May 9, 4:07 PM EDT

Call Control & Record

HOST PIN: 349 0007

you are not on the call

MUTE UNMUTE

Host controls

UNLINK MEETING Conference Recorder

NO JOIN TONES

ENABLE LINK

Shared Documents

Shared documents and links are visible to all meeting participants.

"There are no shared documents for this meeting."

Private Notes & Documents

Private notes and documents are visible only to you.

Documents

"There are no private documents"

Notes

"There are no private notes"

Meeting Recordings

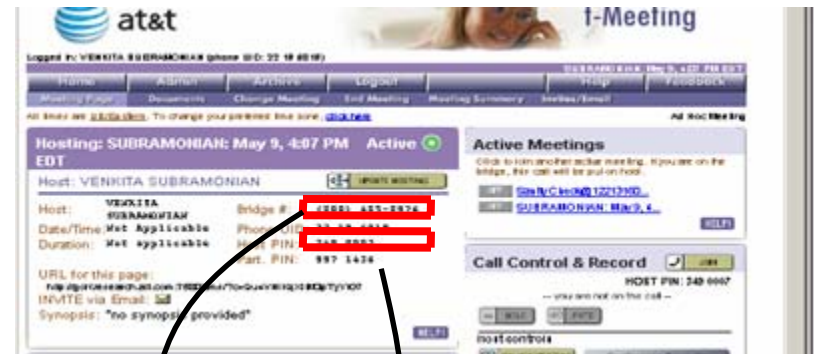
"No recordings are available"

Having problems? Contact [your help desk](#).

© 2007, 2008 AT&T Intellectual Property. All rights reserved.

Done

# Example Functional Test



- Host VoIP:
- Dial bridge #
- Interact with voice prompt
- Enter userid and PIN
- Verify connected to conference

# Example Functional Test



Participant Browser:  
Go to meeting page  
Extract participant PIN

t-Meeting v1.1.1D: SUBRAMONIAN: May 9, 4:07 PM EDT - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://golf.research.att.com:7580/vms/Upda

at&t t-Meeting

Logged in: VENKITA SUBRAMONIAN (phone UID: 22 19 6018)

Home Admin Archive Logout Meeting page Documents Change Meeting End Meeting Meeting Summary Invites/Email

All times are [JJB/Ed/Am](#). To change your preferred time zone, [click here](#).

Ad Hoc Meeting

Hosting: SUBRAMONIAN: May 9, 4:07 PM EDT Active

Host: VENKITA SUBRAMONIAN UPDATE HOSTING

Host: VENKITA SUBRAMONIAN Bridge #: (800) 425-8976

Date/Time: Not Applicable Phone UID: 22 19 6018

Duration: Not applicable Host PIN: 348 0002

INVITE via Email:  Part. PIN: 882 1426

URL for this page: <http://golf.research.att.com:7580/vms/700Qu4VMIkpdMEdTYV10?>

Synopsis: "no synopsis provided"

Active Meetings

Click to join another active meeting. If you are on the bridge, this call will be put on hold.

See My Calendar 12/21/16

SUBRAMONIAN: May 9, 4...

Call Control & Record

HOST PIN: 348 0002

you are not on the call

MUTE UNMUTE

Host controls

UNLINK MEETING Conference Recorder

NO JOIN TONES

UNLINK MEETING

Shared Documents

Shared documents and links are visible to all meeting participants.

"There are no shared documents for this meeting."

Private Notes & Documents

Private notes and documents are visible only to you.

Documents

"There are no private documents"

Notes

"There are no private notes"

Meeting Recordings

"No recordings are available"

Participant List

Speaking:

All participants: Mute all Unmute all

Mute Block On

VENKITA SUBRAMONIAN

One etc ...

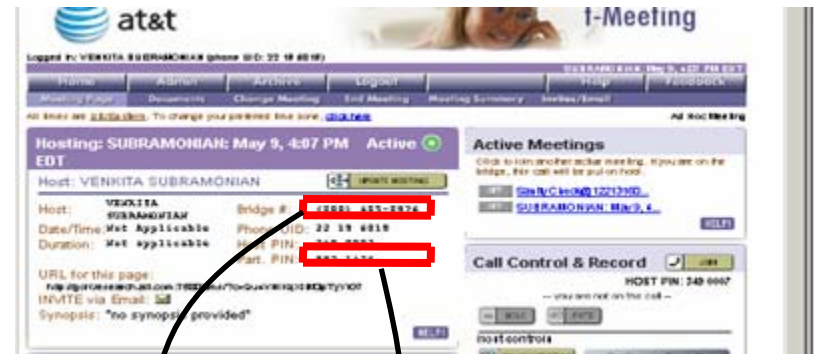
current speaker(s) shown in red

Having problems? Contact [your help desk](#).

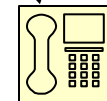
© 2007, 2008 AT&T Intellectual Property. All rights reserved.

Done

# Example Functional Test



Participant VoIP:  
Dial bridge #  
Interact with voice prompt  
Enter userid and PIN  
Verify connected to conference



# Example Functional Test



Host and Participant Browsers:  
Verify host and participant  
shown as joined to conference

|                       | Mute                     | Block                    | On                       |
|-----------------------|--------------------------|--------------------------|--------------------------|
| VENKITA               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| SUBRAMONIAN           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Gerald Karam (gk1943) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| ... Guests ...        |                          |                          |                          |

# Example Functional Test



Host Browser:  
End meeting

Host and Participant VoIP:  
Verify disconnected

t-Meeting v1.1.1D: SUBRAMONIAN: May 9, 4:07 PM EDT - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://golf.research.att.com:7580/vms/Upda

at&t t-Meeting

Logged in: VENKITA SUBRAMONIAN (phone UID: 22 19 8019)

Home Admin Archive **End Meeting** Meeting Summary Invites/Email Help Feedback

All times are [JED/Edison](#). To change your preferred time zone, click on the link.

Ad Hoc Meeting

Hosting: SUBRAMONIAN: May 9, 4:07 PM EDT Active

Host: VENKITA SUBRAMONIAN UPDATE HOSTING

Host: VENKITA SUBRAMONIAN Bridge #: (202) 425-2976

Date/Time: Not applicable Phone UID: 22 19 8019

Duration: Not applicable Host PIN: 345 0007

Part. PIN: 997 1426

URL for this page:  
<http://golf.research.att.com:7580/vms/70-QuaVMIkqDlMCPYY107>  
INVITE via Email:

Synopsis: "no synopsis provided"

Active Meetings

Click to join another active meeting. If you are on the bridge, this call will be put on hold.

Subramonian, May 9, 4:07 PM EDT

Call Control & Record

HOST PIN: 345 0007

you are not on the call

Host controls

Unmute Meeting Conference Recorder

No Join Tones

Private Notes & Documents

Private notes and documents are visible only to you.

Documents

There are no shared documents for this meeting.

Notes

There are no private notes.

Meeting Recordings

No recordings are available.

Participant List

Speaking:

All participants: Mute all Unmute all

Mute Block On

VENKITA SUBRAMONIAN

current speaker(s) shown in red

Having problems? Contact [your help desk](#).

© 2007, 2008 AT&T Intellectual Property. All rights reserved.

Done

# Automated Functional Testing Requirements

Web and SIP protocol endpoints can be instantiated

Test agents can concurrently process protocol messages from SUT

Concurrent test agents can be coordinated to achieve the necessary sequence of interactions with the SUT

VoIP test agent can interact with voice prompt menu

HTML page can be parsed and specified content extracted

Information extracted from one test agent can easily be passed to another

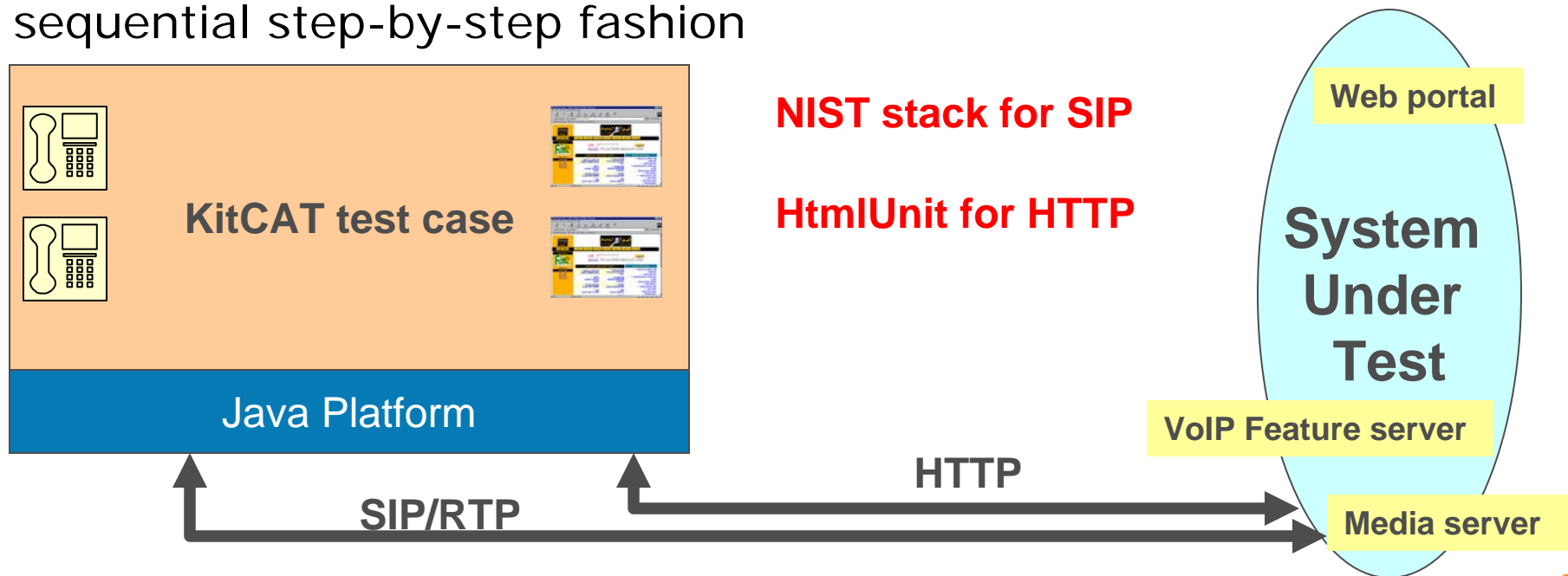
# What is KitCAT?

A Java framework that aids automated functional testing of converged applications

Created by AT&T Research and available open source

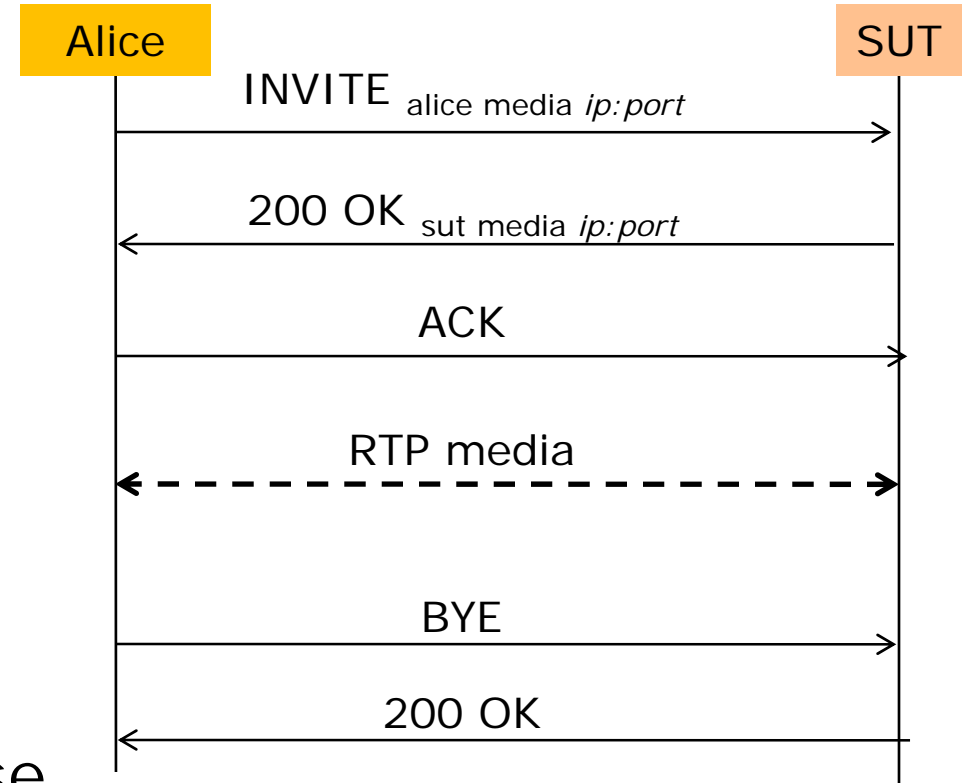
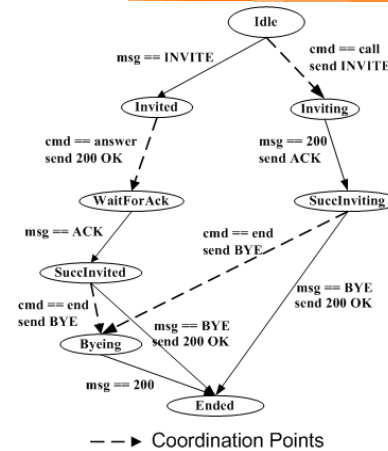
<http://echarts.org/KitCAT>

KitCAT enables a user to write a converged test case in a sequential step-by-step fashion



# SIP Testing

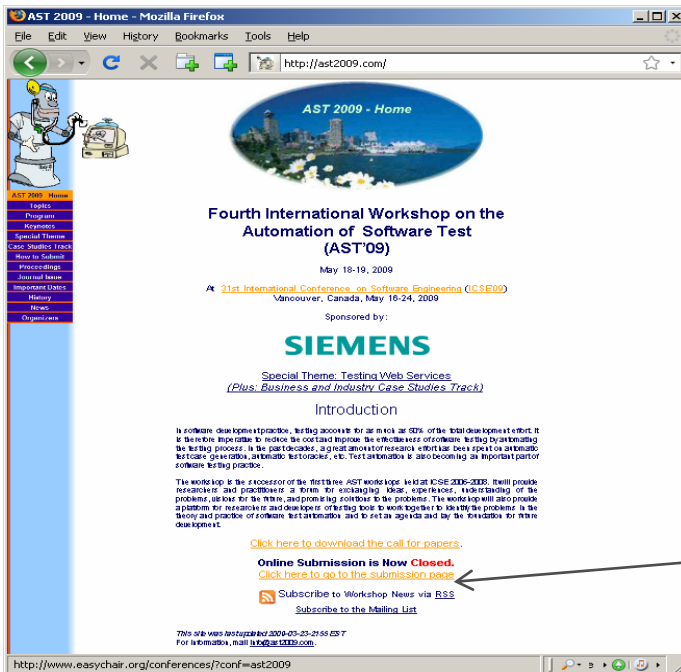
```
SIPAgent alice = createAgent("Alice");
alice.setProxy("sut.att.com");
alice.call("sip:bob@research.att.com");
pause(2000);
assertThat(alice, connected());
pause(2000);
assertThat(alice, has (incomingMedia()));
pause(2000);
alice.sendDTMF("1234");
pause(2000);
alice.end();
pause(2000);
assertThat(alice, disconnected());
```



Excerpt from KitCAT test case

# Web Testing (1/3)

HtmlUnit provides API for web testing



Need to navigate to the submission page

```
WebClient wc = new WebClient();
HtmlPage page = (HtmlPage) wc.getPage("http://ast2009.com");
HtmlAnchor anchor = page.getAnchorByHref(
    "http://www.easychair.org/conferences/?conf=ast2009");
anchor.click();
```

## Web Testing (2/3)

HtmlUnit supports XPath expressions

```
List l = page.getByXPath(  
    "//a[contains(., 'Click here to go to the submission page')]");  
Iterator it = l.iterator();  
anchor = (HtmlAnchor) it.next();  
anchor.click();
```

From the root of the HTML document tree, get anchor elements with the specified text as their value

## Web testing (3/3)

### Application-specific abstractions

```
public HtmlPage goToSubmissionPage(HtmlPage homePage) {  
    List l = homePage.getByXPath(  
        "//a[contains(., 'Click here to go to the submission page')]");  
    Iterator it = l.iterator();  
    anchor = (HtmlAnchor) it.next();  
    return anchor.click();  
}
```

# t-meeting Web Test Abstractions

login

createMeeting

goToMeetingPage

deleteMeeting

dropParticipant

removeParticipant

muteParticipant

blockParticipant

muteAll

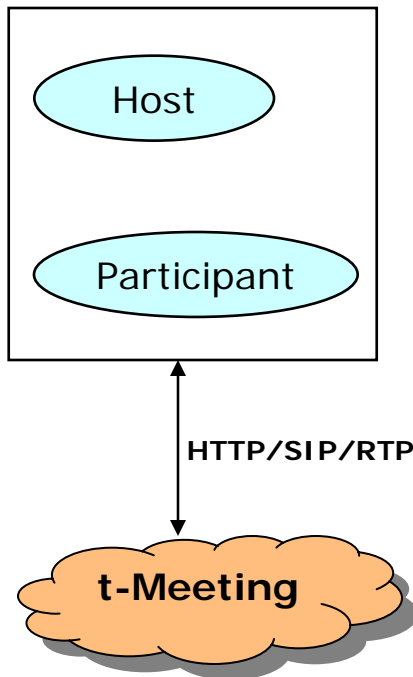
unmuteAll

turnRecordingOn

turnRecordingOff

# Converged Functional Testing (1/2)

## KitCAT test case



```
SIPAgent host = createAgent("Host");
```

```
SIPAgent part = createAgent("Part");
```

### //1. AT&T Global login

```
TMeetBrowser browser = new TMeetBrowser();
```

```
TMeetHomePage homePage = browser.login(env, userid, passwd);
```

### //2. create ad-hoc meeting

```
HostMeetingPage meetPage = (HostMeetingPage) homePage.createAdhocMeeting();
```

### //3. get PINs, conference bridge number from the meeting page

```
String meetingName = meetPage.getMeetingName();
```

```
String bridgeNum = meetPage.getBridgeNumber();
```

```
String hostUid = meetPage.getPhoneUID();
```

```
String partUid = "07111943";
```

```
String hostPin = meetPage.getHostPin();
```

```
String partPin = meetPage.getParticipantPin();
```

### //4. Host joins conference

```
host.call("sip:" + bridgeNum + "@" + appServer);
```

```
pause(3000);
```

```
assertThat(host, is (connected()));
```

```
pause(3000);
```

```
host.sendDTMF(hostUid + "#");
```

```
pause(3000);
```

```
host.sendDTMF(hostPin + "#");
```

```
pause(1000);
```

### //5. Participant joins conference (not shown)

Application-specific  
abstractions

Easy to simulate  
DTMF key presses

Easy information passing  
among test agents

# Converged Functional Testing (2/2)

ability to send RTP media

```
pause(20000);
```

**//6. check meeting web page to assert host and participant are shown as joined**

```
assertThat(meetPage, has( participantJoined(hostUserName)));
```

```
assertThat(meetPage, has( participantJoined("GERALD")));
```

**//7. check various functions in the meeting page**

```
meetPage.turnRecordingOn();
```

```
host.playAudio("howdoin.raw");
```

```
pause(10000);
```

```
meetPage.turnRecordingOff();
```

```
pause(10000);
```

```
assertThat(meetPage, has (recordingAvailable()));
```

**//8. Host ends meeting from web**

```
meetPage.endMeeting();
```

```
pause(20000);
```

**//9. Assert meeting ends (both web and SIP)**

```
assertThat(meetPage, has (ended()));
```

```
assertThat(host, is (disconnected()));
```

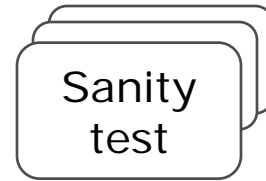
```
assertThat(part, is (disconnected()));
```

assertions on web agents

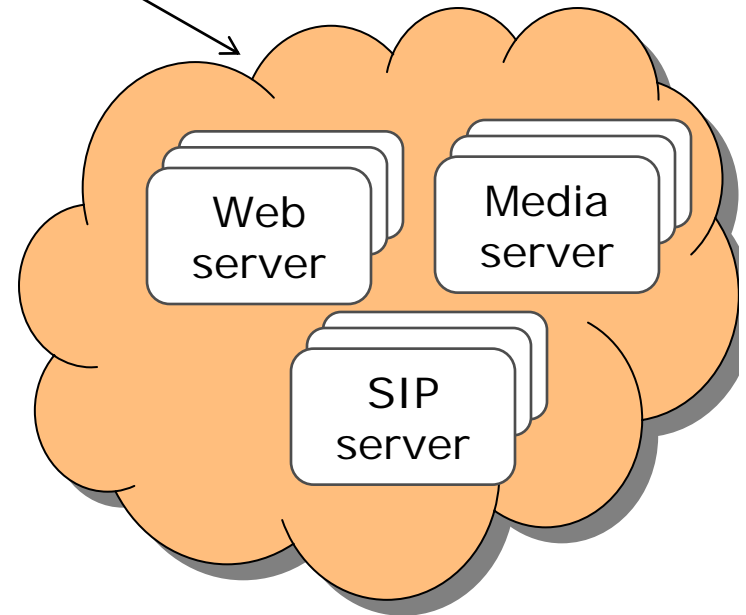
assertions on SIP agents

# Sanity Tests (24 x 7 every 5 min)

Plays a very effective role for ensuring functional integrity of application in production



SIP/RTP/HTTP



Mozilla Firefox browser window showing a table of test results. The table has columns for Date/Time and various test identifiers (DIAL, 051-058, 072-073, 048-049, 050). All test results are "PASS".

| Date/Time        | DIAL | 051  | 052  | 053  | 054  | 055  | 056  | 057  | 058  | 072  | 073  | 048  | 049  | 050  |
|------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2008-04-21-16:38 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:33 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:28 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:23 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:18 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:13 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:08 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-16:03 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:58 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:53 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:48 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:43 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:38 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:33 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:28 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:23 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:18 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:13 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |
| 2008-04-21-15:08 | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS | PASS |

## Conclusion and Future Research Ideas

KitCAT is a powerful open-source solution for functional testing of converged applications

Minimize dependency of application-specific abstractions on structure of HTML

- Test specific annotations in the HTML page
- Implement high-level abstractions using embedded JavaScript in the web page

Domain Specific Language (DSL) for converged testing

Automatic test generation

- Captured message trace
- Analysis of converged application written in formal language e.g. StratoSIP

Thanks!!

<http://echarts.org>