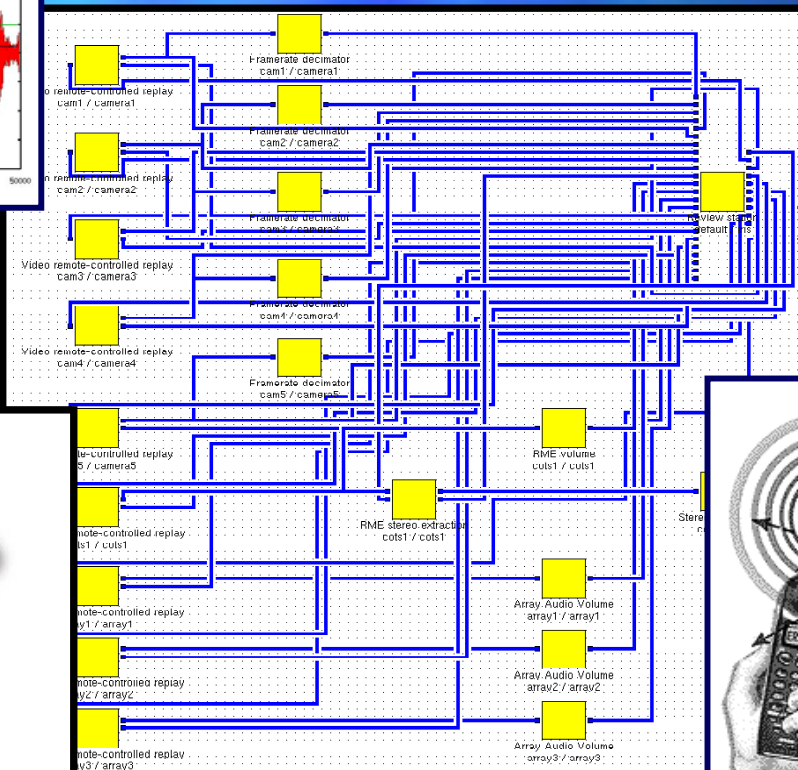
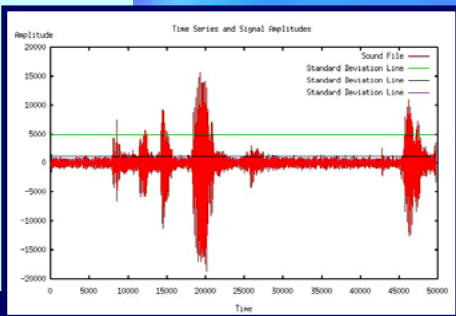


Pervasive Computing offers Adaptable Interfaces

Signals, Standards, Metadata, and ICADI

June 26, 2003



Pervasive Computing Program

The Next Wave of Information Technology...

INFORMATION TECHNOLOGY LABORATORY

This has already gone live

Elite Care - Elder Care Delivery

- Wired residential buildings
- Locator badges, with IR & RF can be used to summon aid
- Health trend data capture: weight, administration of medicines
- Sensors, e.g.: weight sensor in beds, track wakefulness, sudden changes
- Reduced staff turnover, more effective resource allocation, better monitoring, lower costs



Research Interfaces Can Also Contribute

- Visionary system concepts, like oxygen, HPCS, Cognitive, and Pervasive systems offer essential road maps
- But real challenges remain to developing *perceptive* systems that:
 - *Sense* user signals like speech, gesture, and physiological measurement
 - *Recognize* words, speakers, gestural referents
 - *Understand* context, and user intent
 - *Respond* with information retrieval, computation, and rendering

NIST Smart Space and Meeting Room Projects

Smart Space data:

- Multi modal multi channel data acquisition and transport
- Distributed processing
- DSP Preprocessing:
 - Signal conditioning
 - Beam forming
 - Feature extraction
- Time tagging
- Archival storage
- Retrieval

Meeting Room metadata:

- Meeting data sets
- Multi level annotation, e.g.
 - Capitalization
 - Acronym detection
 - Proper noun detection
 - Sentence/utterance boundary detection
 - Filled pauses
 - Verbal edits (repeats, restarts, revisions)

Smart Spaces – What's Real?

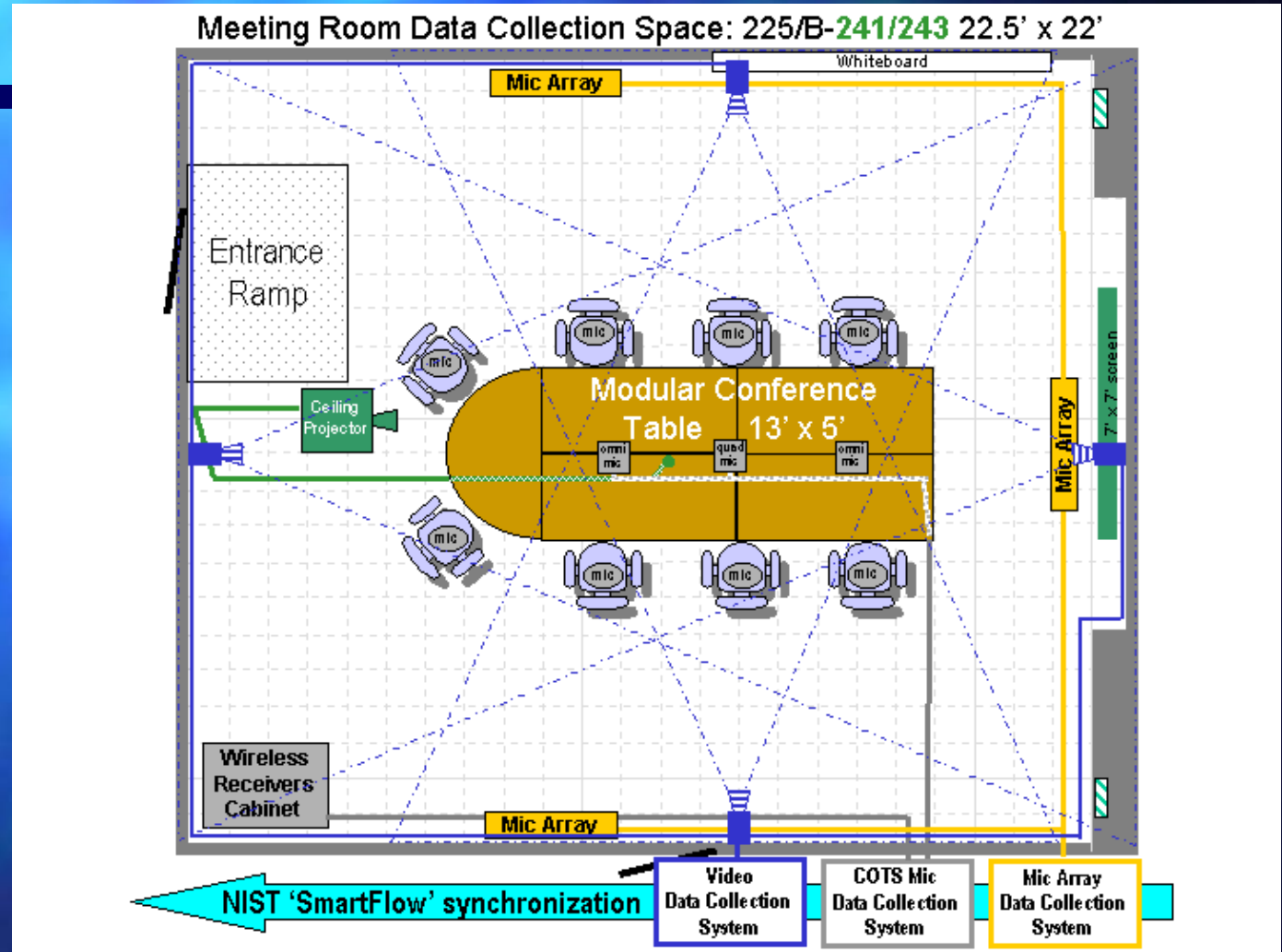
- Speech recognition possible using microphone arrays *for skilled speakers*
- Speech segmentation and speaker verification possible
- A selected skilled user can be transcribed in a cooperative group
- Transcribed speech can be parsed for basic commands

Meeting Room Data Collection Laboratory

- **Phased microphone arrays**
- **Computer-controlled video cameras**
- **Biometric sensor fusion using commercial components:**
 - **Acoustic speaker identification**
 - **Facial image classification**
- **Speaker dependent speech recognition**
- **Data flow test-bed for integration of commercial products**

NIST Meeting Room Data Collection Facility

Over 200
Acoustic and video
sensors
Generating
about 70 GB/Hr



Multi modal Meeting Recording

- Collect and review recordings

- Open system-based, interfaces with Smart Data Flow live or from archived data

- User selects video views and audio channels

- User controls camera view/movement

1 TMM1
2 TMM2
3 QTM1
4 QTM2
5 QTM3
6 QTM4
7 None
8 TMM3
q Head 1
w Lapel 1
e Head 2
r Lapel 2
t Head 3
y Lapel 3
u Head 4
i Lapel 4
a Head 5
s Lapel 5
d Head 6
f Lapel 6
g Head 7
h Lapel 7
j Head 8
k Lapel 8
z HeadMix

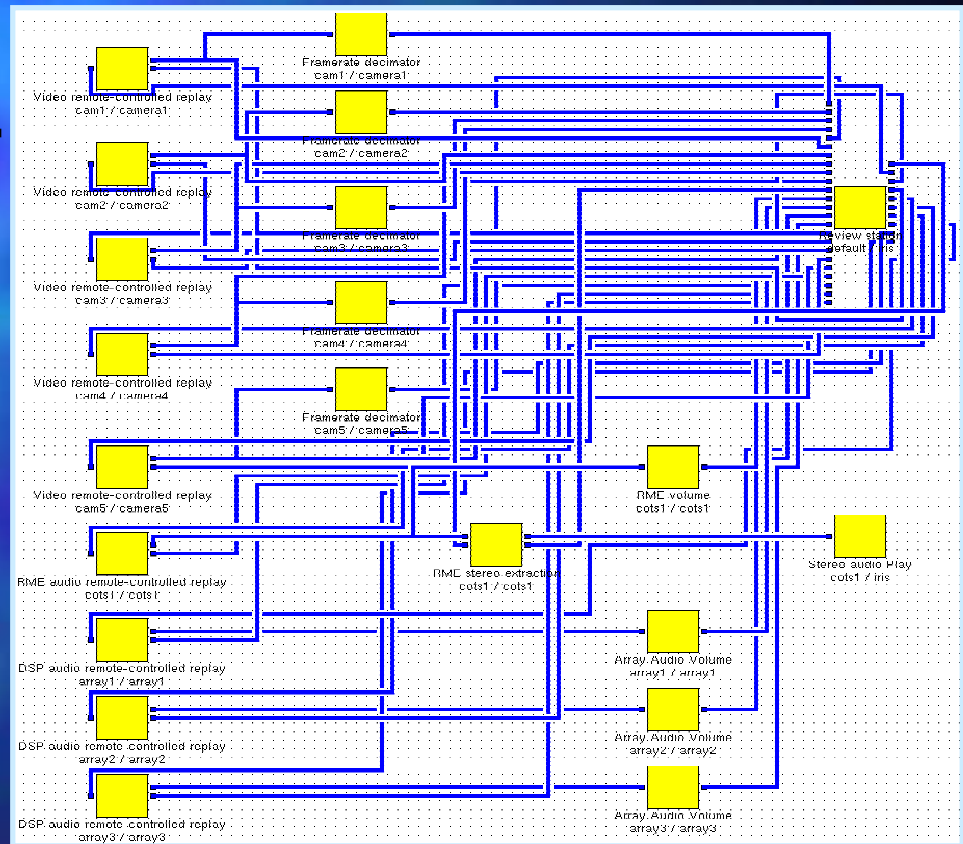
0 Left
- Both
= Right

< Vol >

2002-03-19
14:32:29.4

NIST Smart Data Flow Middleware

- Data transport as *buffered data flows* suitable for real time
- High-bandwidth, multi-sensor data on distributed clusters
- Native support for basic data types
 - Audio, video, vector, matrix, and opaque (raw data)
- Can route data to remote clients and archives
- Flows time tagged to millisecond resolution using NTP
- Visual facility for connecting Smart Data Flow clients



NIST Smart Data Transport Abstraction for Buffered Real Time Connectivity

```
#include "preem.h"
static double history;

int main(int argc, char **argv){
    preem_init(&argc, argv);
    history = 0;
    preem_run();
    return 0;
}

void preemphasis(const double *in, double *out)
{
    int i;
    out[0] = in[0] - 0.97*history;
    for(i=1; i<FLOW_SIZE; i++)
        out[i] = in[i] - 0.97*in[i-1];
    history = in[2047];
}
```

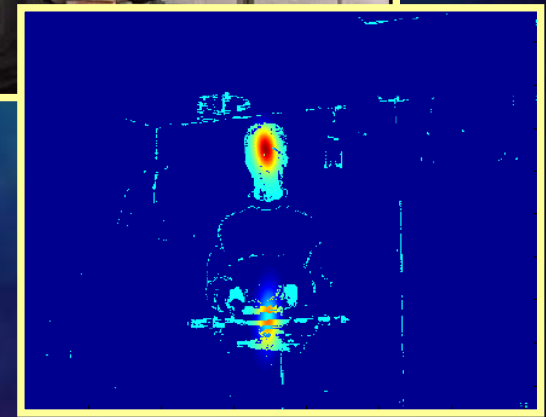
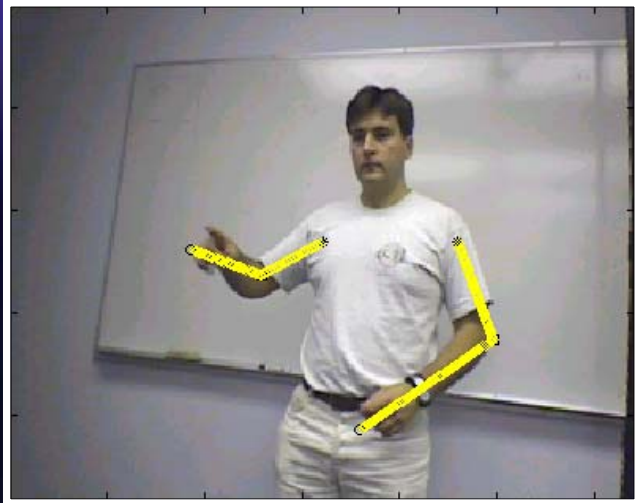
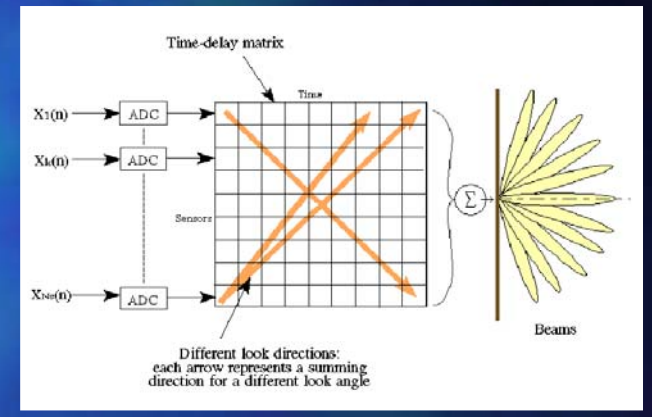
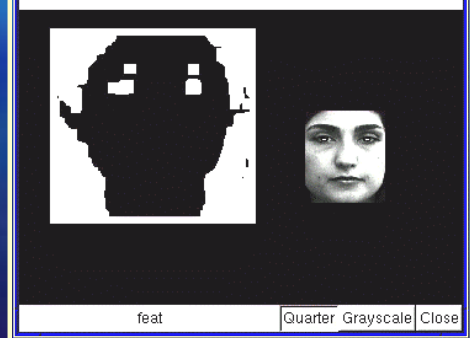
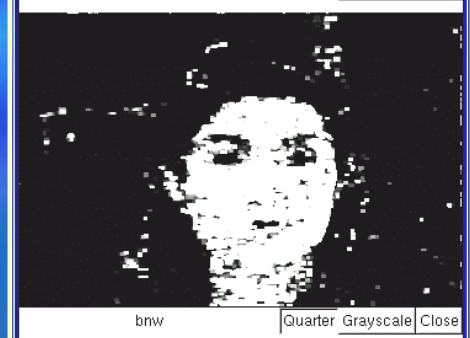
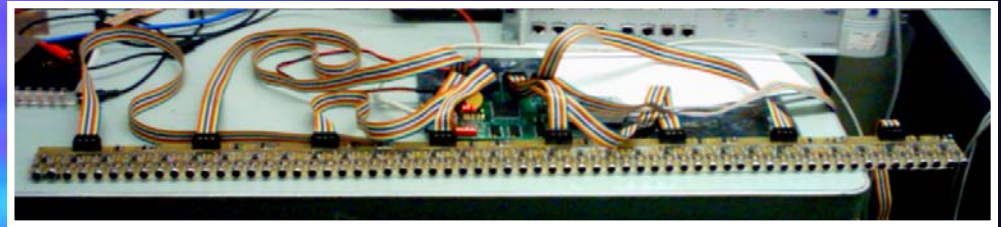
**"Hello World" of
data flow**

**Client
Run Loop**

**Distributed
I/O flows**

**Simple
Digital Filter**

Multi Modal Sensors



The NIST Test Bed for Industrial Smart Space Technologies

- **Multiple microphones, arrays**
 - Speaker identification
 - Speech recognition
 - Source bearing estimation
 - Close talk, lapel, tabletop, and distant microphones
- **Video cameras, arrays**
 - Person finding
 - Face localization and identification
 - Gesture recognition
- **Open source data flow transport and standardization**
- **Performance metrics**

Usability Features

NIST Smart Data Flow System

- **Initial version was difficult to deploy and use – New version under development:**
 - **Visual flow graphs**
 - **Code generator**
 - **Simplified API**
 - **Device, user, and service discovery**
 - **Fault tolerant**

NIST Mark-II Microphone Array

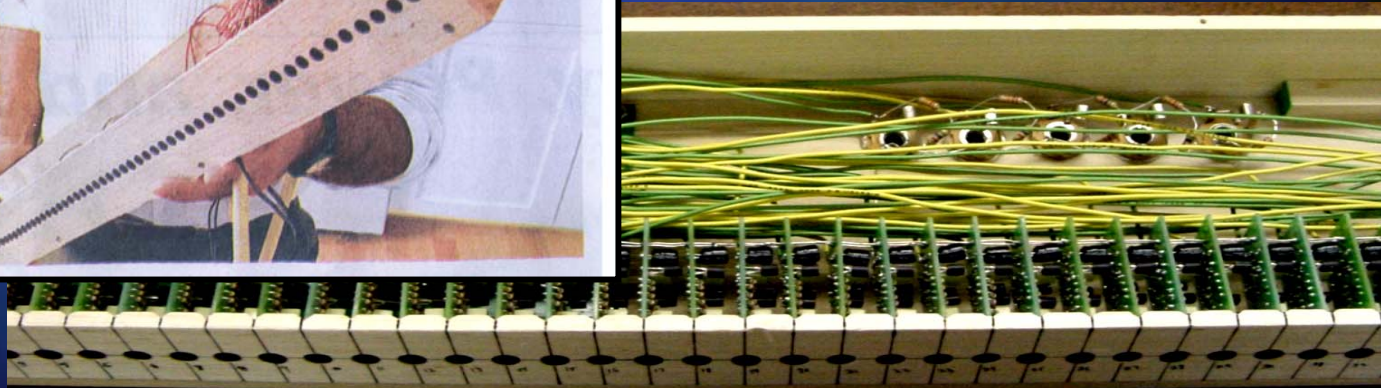
Fragile and Hard to Duplicate

THE NEW YORK TIMES, THURSDAY, APRIL 5, 2001

'Smart' Home Eases Elder Care

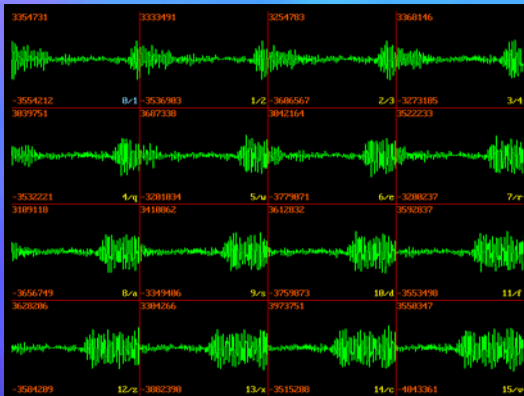


**Mark-II
Microphone Array
at GA Tech**



The Mark-III Microphone Array

Integrated, Easy to Replicate



- VLSI, FPGA, VHDL, Preamps, ADCs
- 64 channel, 24bits at 48kHz
- 2Mbyte local data buffer
- BOOTP IP negotiation
- Fast Ethernet data transmission
- Responds to Smart Data Flow System: array ID, receiving node, array active indicator, etc.

Smart Space Prototype

Technologies

- **Integrated industrial components:**
 - IBM speech recognition
 - Intel OpenCV face recognition
 - Wireless networking
- **Unique sensor arrays for data acquisition:**
 - Beam forming
 - Source localization
 - Acoustic/video sensor fusion
- **Large scale data collection for smart space R&D**

Sensors Will Allow Personal Interfaces

- Current interfaces are *nominal* – who presses the buttons does not matter
- Sensor based interfaces can be *personalized*
 - *Recognize* – who said what, gestures etc.
 - *Understand* – what did it mean in context
- “Computer, bring up my appointment calendar.”
- *Customized to user mode preferences*

Vision of the Possible:

An Accessible Meeting Room That...

- **Takes the minutes** from the moderator
- **Responds to commands**, depending on who spoke, what they were looking at, or pointing to
- **Accesses information** by voice query
- **Provides security** based on participant identity
- ***Completely Hands free***

Accessibility Prototype: *Hands Free Services*

- User device discovery
- Hands free preference negotiation
- Service discovery:
 - Microphone array
 - Speaker ID
 - Speaker dependent speech recognition
- Upload biometric profiles for recognition
- Distributed data acquisition and processing

PDA Integration for *Accessibility* Experiments

Data Flow



Wireless PDAs

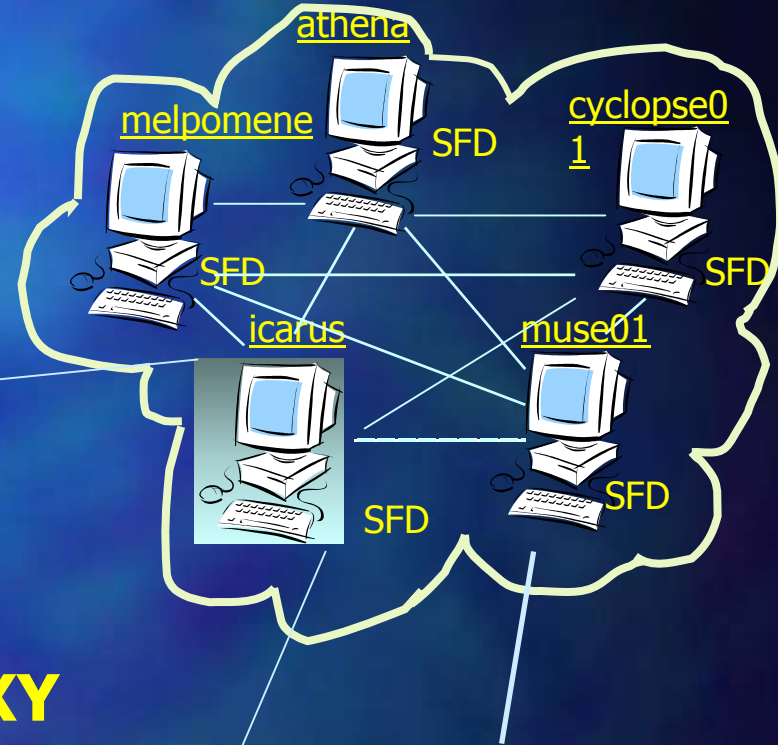
Qt Clients

**HTTP Request Via
Wireless 802.11
network**



HTTP PROXY

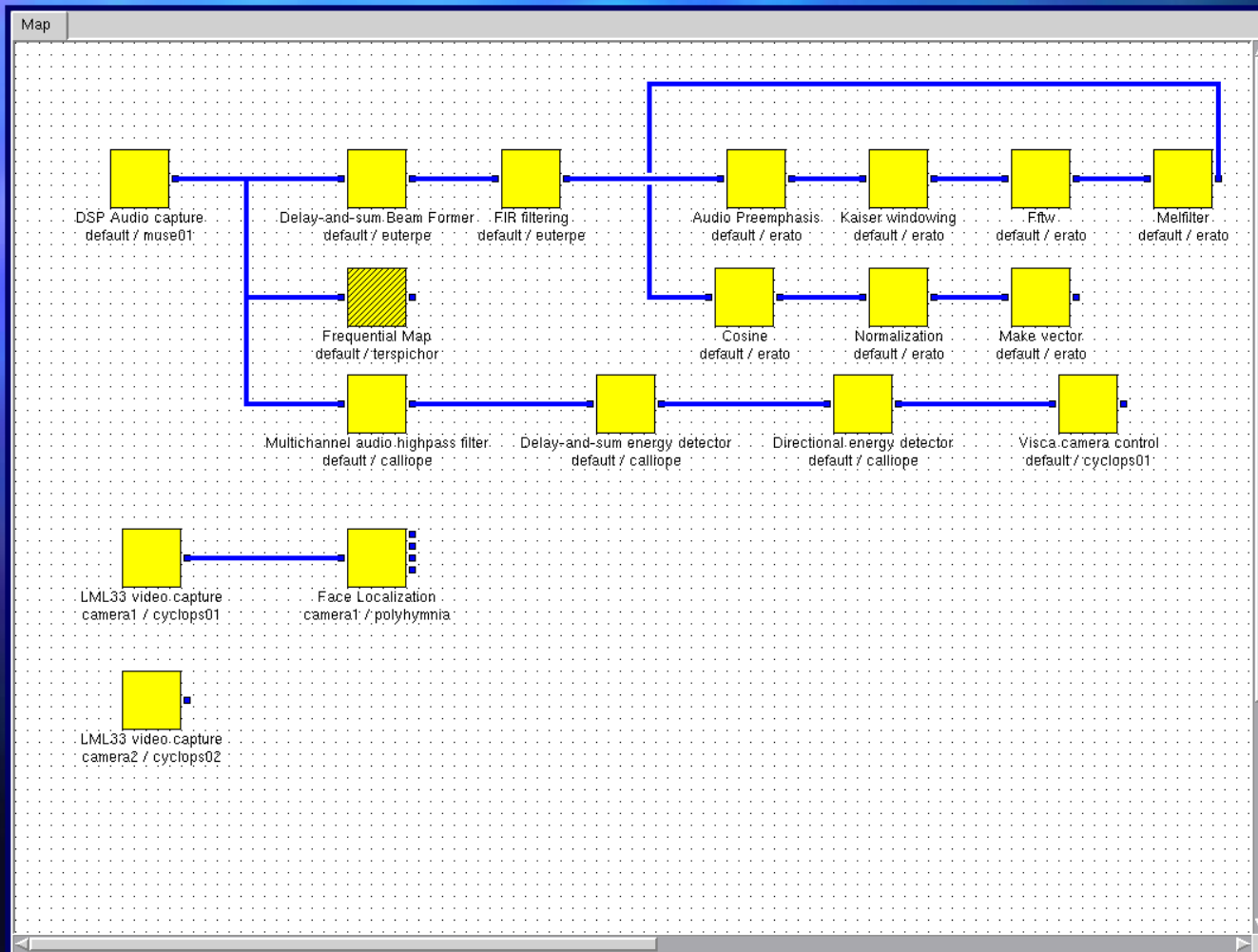
**CGI Program
Smart Flow
Gateway**



Personalized User Interfaces: ***User Discovery***

- **Automated device/service discovery using INCITS V2 preference protocol:**
 - Hands free
 - Eyes free
 - Ears free
- **Define appropriate multi modal service responses:**
 - Speaker ID and speech recognition
 - Screen Reader with Braille or TTS output
 - Automatic meeting captioning

Example: Speaker ID Flow Graph



- Array data capture
- Source bearing
- Beam forming
- Cepstrum pipeline
- Speaker ID
- Camera steering

What Can NIST Do for this Community?

- Chartered to enhance industrial technology using measurements and standards
- Be a *neutral* moderator of industry/academic partnerships
- Provide advanced metrology, advice
- Cooperatively produce standard reference data
- Publish measurement algorithms and protocols
- Publish non-regulatory standards embodying community agreements

Measurements and Standards Will be Key...

- Performance metrics
- Standardized integrating platform:
 - Data formats
 - Transport mechanisms
 - Distributed computing
 - Adaptive interfaces for the disabled
- Contact stanford@nist.gov if you are interested in a working group

Questions

- Your Thoughts?
- Your Experiences?