Integrating Sound and Multi-Media with X

MAS: The Media Application Server

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Tested Release Candidate 1

“Whirled Peas”

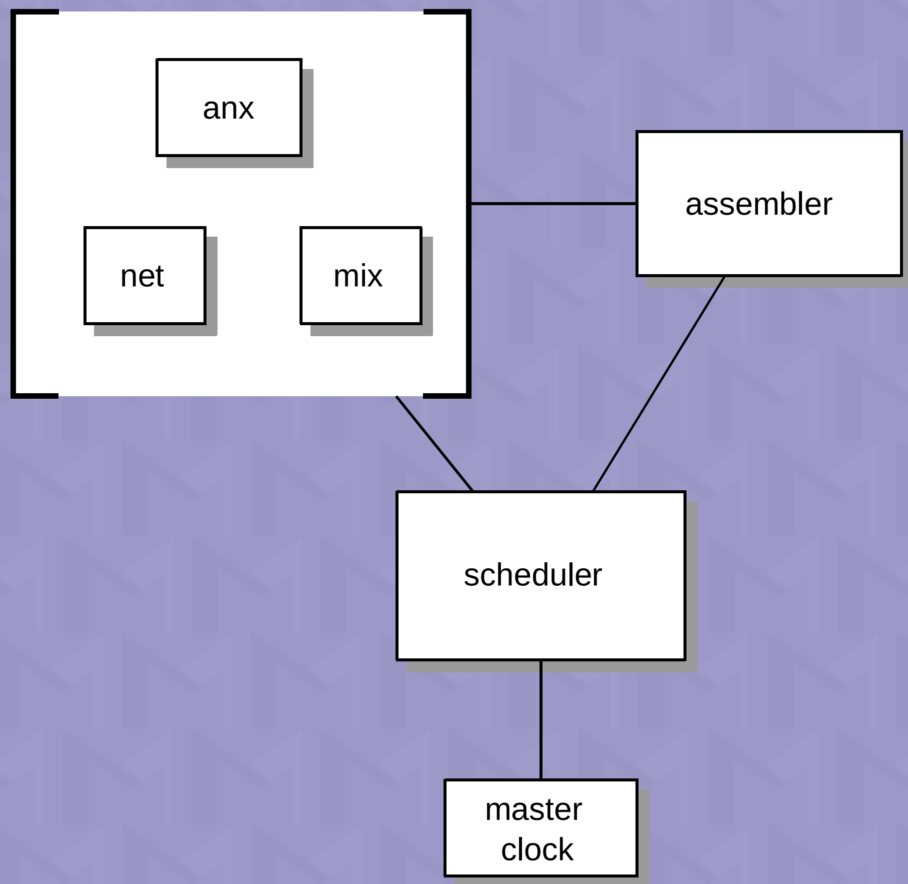
Target: January 1, 2003

for integration into X11R6.7, March 2003

The MAS Architecture is Different

- MAS *is* a sound and multimedia server
- Networking and RTP are fundamental
- More peer-to-peer than client-server
- Our core dependency is ANSI C89
- MAS anticipates the need for very complex assem-blages
- Single-threaded, centralized scheduler
- Timing and performance monitoring are integral
- Required support for accessibility

The MAS Process



The MAS Architecture

- ***Devices*** are dynamically loaded MAS plug-ins
- Data is communicated between devices using MAS ***ports***
- Work is done by ***actions*** that devices implement.
- Actions are triggered by the ***scheduler***.
- The ***assembler*** manages the scheduler's ***event queue*** for the set of devices in an ***assemblage***.
- The ***scheduler*** acts on the queue of ***events***.
- An ***application*** is a combination of devices and client processes.

History and Goals
In the Beginning

The solution needs to consider X11's features:

- Operable on many platforms
- Network transparent
- Open source core, allowing for proprietary releases
- Developed within a standards body

History and Goals

- Scale to the smallest and the biggest
- Everything is an extension - dynamic loading from the outset
- Functionality can scale as you need it
- Separation of data and control
- Enable very simple application construction out-of-box
- It needs to have good documentation.

The User Interface

GNOME, KDE, CDE...

MAS is agnostic.

MAS: Syntax and Semantics

server

client

process

application

Accessibility Requirements

- Controllable, low latency
- Stopping utterances quickly
- Multiplexing, with priorities
- High audio quality
- Small memory footprint
- Format independent media handling
- Synchronization of multiple media streams

Synchronization and Latency
A Basic Requirement

- ABC, CBS, NBC say no worse than audio 33ms lagging behind video or 16ms leading video
- EIA/TIA say -40ms, +25ms.
- Possible POTS delay: 50ms
- Satellite phones: 250ms
- Multiple audio sources, same room: discernible echoes after 55ms, reverberation between 10ms and 55ms, phase distortion less than 10ms.

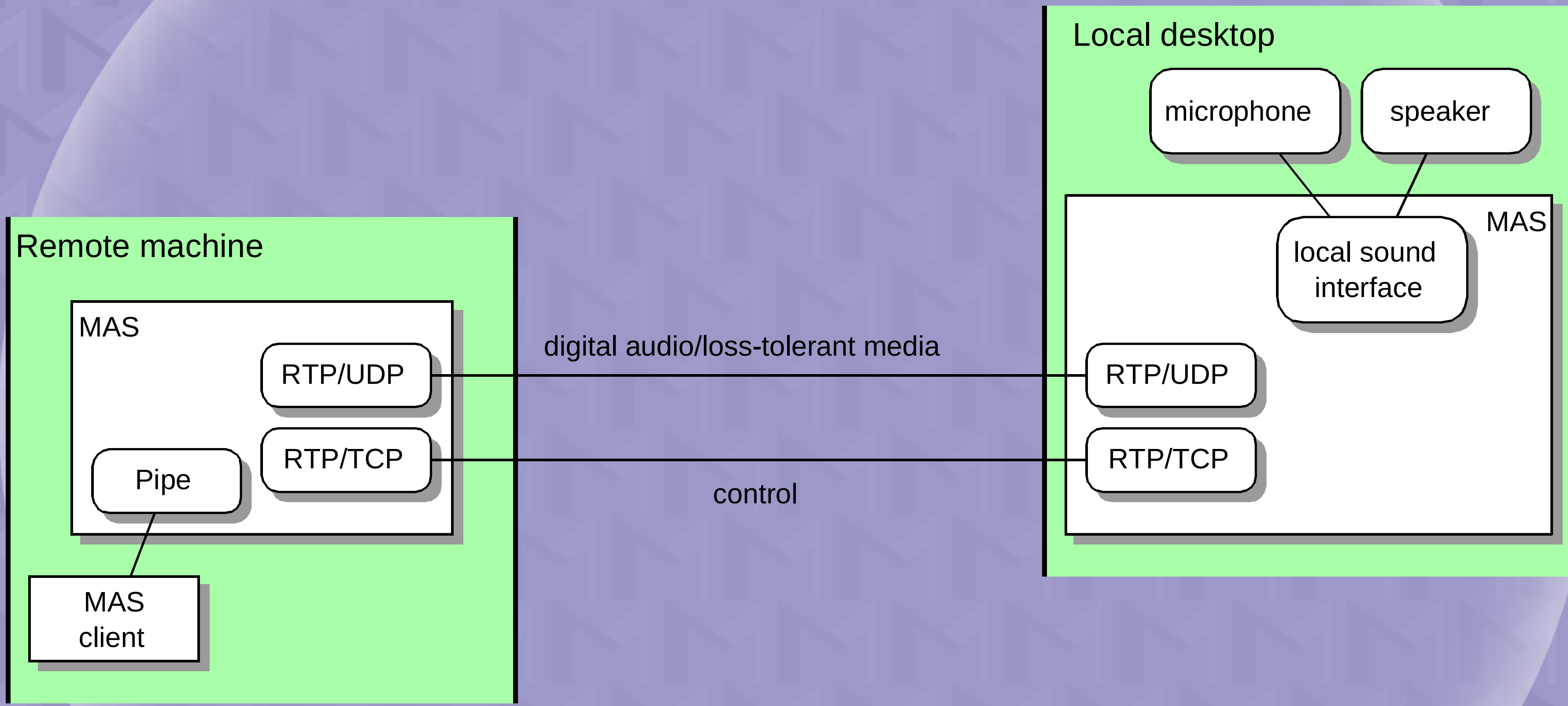
The Real Time Protocol (RTP)
RFC 1889, January 1996

- It's almost an Internet Standard
- Carries time-sensitive information: audio, video, events, etc.
- Timestamping in Network Time Protocol (NTP) format
- ... and, simultaneously, with media-specific clocks
- There's no reason to re-invent the wheel!

RTP and MAS

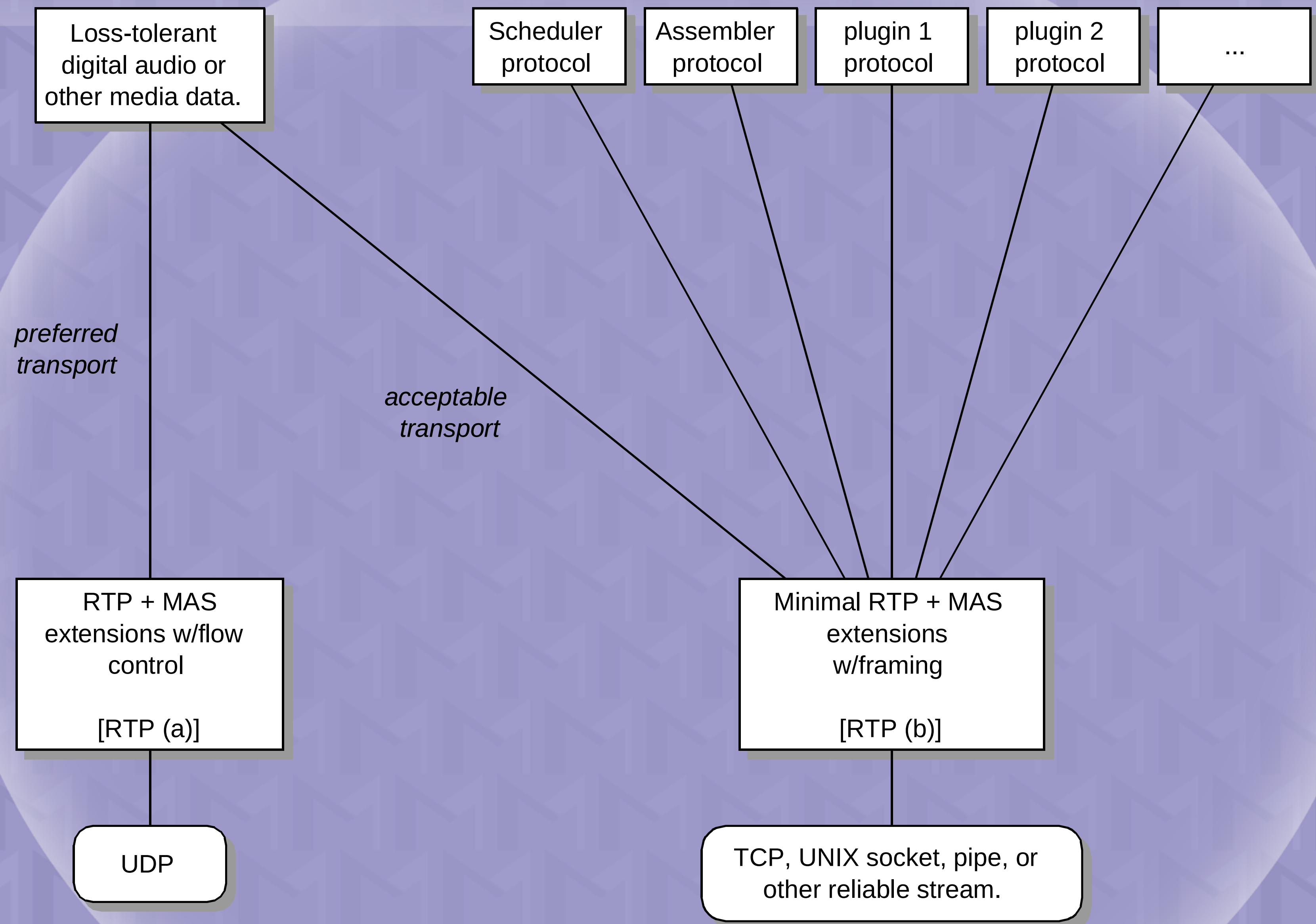
- MAS uses RTP for all communications.
- The transport that carries RTP is unspecified.
  Currently, we're running RTP over UDP, TCP, and UNIX-domain sockets.
- MAS control packets have their own RTP payload type.
- Media formats use pre-defined RTP profiles, when applicable.
  Several defined in RFC 1890, others in subsequent "RTP Profile" RFC's
- MAS doesn't use RTP in a multicast mode, or even typically in a multi-participant session mode.

RTP and MAS



Local desktop
microphone
speaker
MAS
local sound interface
Remote machine
MAS
RTP/UDP
digital audio/loss-tolerant media
RTP/UDP
RTP/TCP
RTP/TCP
Pipe
control
MAS client

RTP and MAS


Loss-tolerant digital audio or other media data.
Scheduler protocol
Assembler protocol
plugin 1 protocol
plugin 2 protocol
...
preferred transport
acceptable transport
RTP + MAS extensions w/flow control
[RTP (a)]
Minimal RTP + MAS extensions w/framing
[RTP (b)]
UDP
TCP, UNIX socket, pipe, or other reliable stream.

The MAS Protocol
Or, really, protocols...

- All entities in the system read and write structures with broken-out RTP headers and packet payloads
- We use a simple public interface for packing and unpacking
- But, you can use whatever you want.
- Device APIs and devices simply need to speak the same protocol.
- MAS comes with pre-defined protocols for its fundamental devices - CODECs, sources, filters, etc.
- These can be extended, or simply not used.

Simple “thru” Devices

- ***endian*** - convert multi-byte linear audio samples to and from little, big, and host endian formats
- ***codec_ulaw*** - convert 16-bit linear audio samples to and from the logarithmic, 8-bit u-law format.
- ***channelconv*** - convert mono to stereo and back.
- ***squant*** - quantize samples to other sample resolutions (e.g. 16-bit to 8-bit) with selectable noise shaping.
- ***srate*** - resample linear audio at a different sampling rate (e.g. 44100 Hz to 48000 Hz), selectable quality.

Virtually Expanding Devices

- ***mix*** - Mixes N linear audio streams down to one audio stream.
- ***split*** - Generates N audio streams from one audio stream.

The Network Device

- Moves data to and from network ports and MAS ports
- Connects to other servers
- Accepts connections from MAS client applications and other MAS processes

A Complete CODEC Has Three Devices

MPEG-1 Audio (including layer 3)

- ***mp1a_source*** - reads from a local file, stuffing an integral number of MPEG frames in each packet. It understands the inter-frame timing relationships.
- ***mp1a_codec*** - decodes incoming frames to their original format (e.g. 44kHz, 16-bit, linear, stereo) or encodes linear audio to the selected MPEG-1 format.
- ***mp1a_sink*** - receives packetized MPEG-1 frames, writes them to disk.

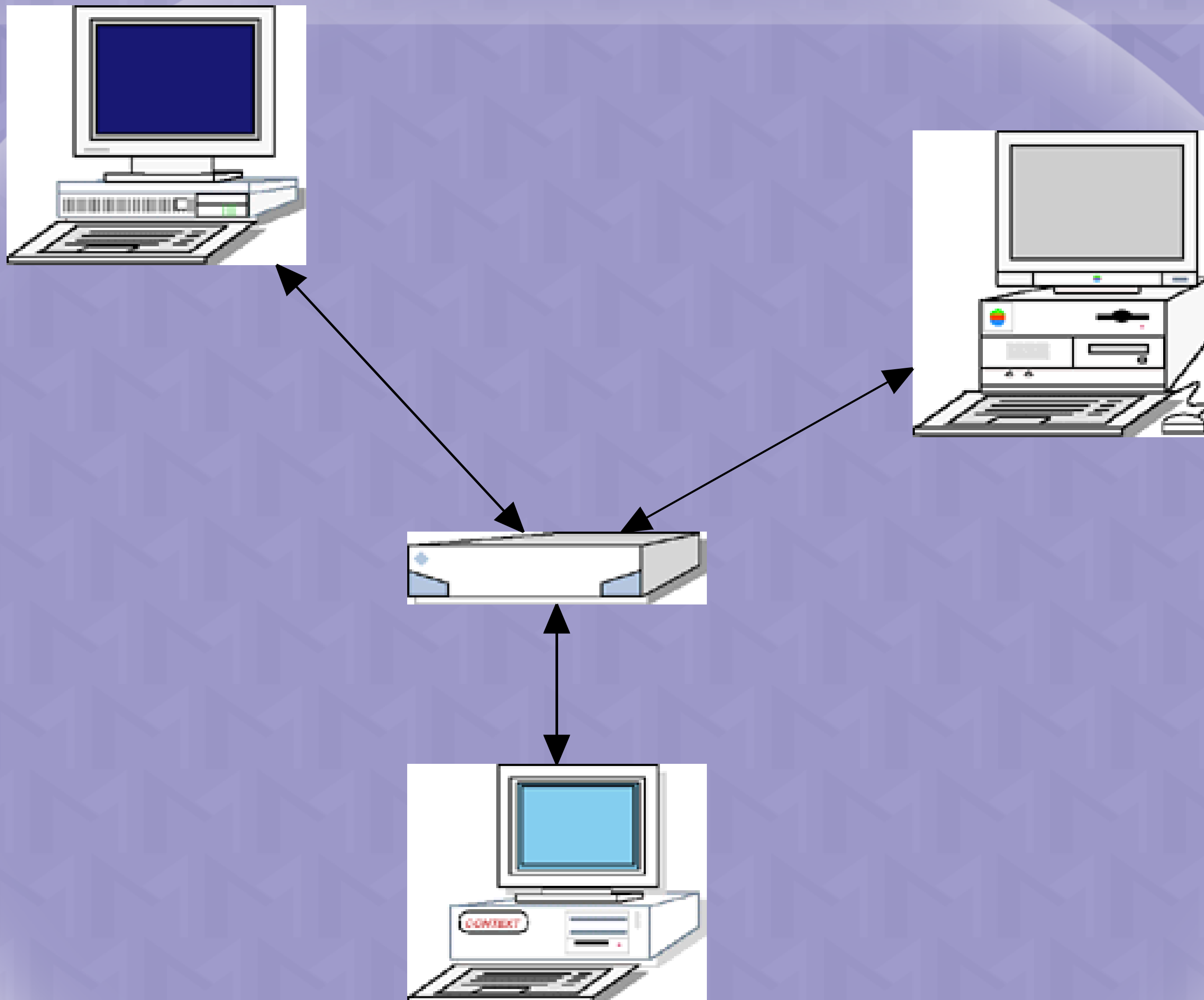
Metering Devices

- ***ppm*** - (Peak Program Meter) is a “thru” device that posts audio signal peak information to a source port - it can be connected to a client via the net device or to another device in the server. Adjustable integration and decay time.
- ***visual*** - X11 visualization device, with spectrum analyzer mode. Linked directly with Xlib, it opens a window on the local X server.

Control-Only Devices

- ***tag*** - given an mp3 filename, supplies the ID3 tag metadata.
- ***interact*** - organize an N-way conference: receives join or leave actions from participants, manages connections to everyone's mixers from everyone's sinks.

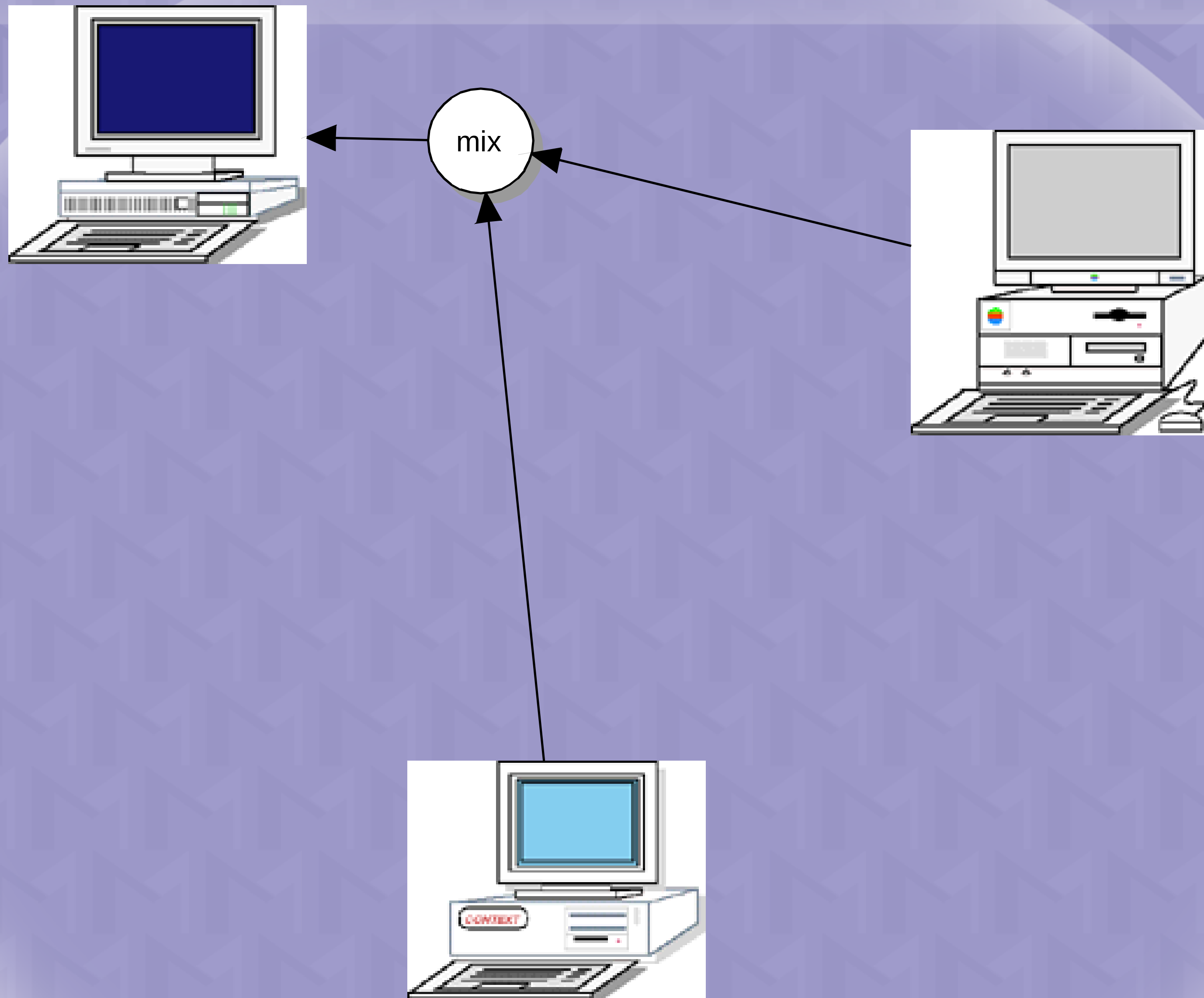
N-Way Conferencing With a Hub Server



SAI Shiman Associates Inc

X.Org

N-Way Conferencing (continued)



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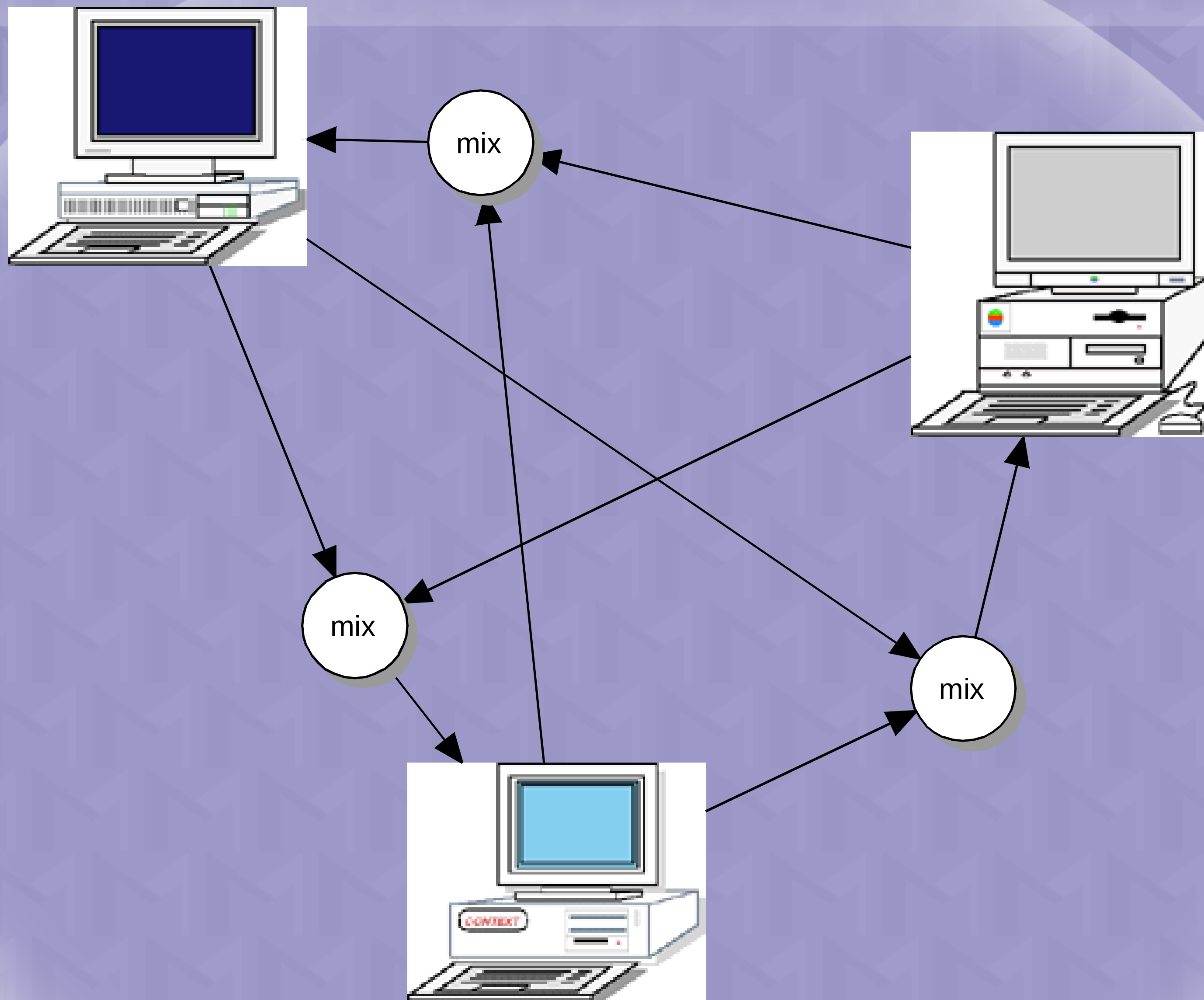

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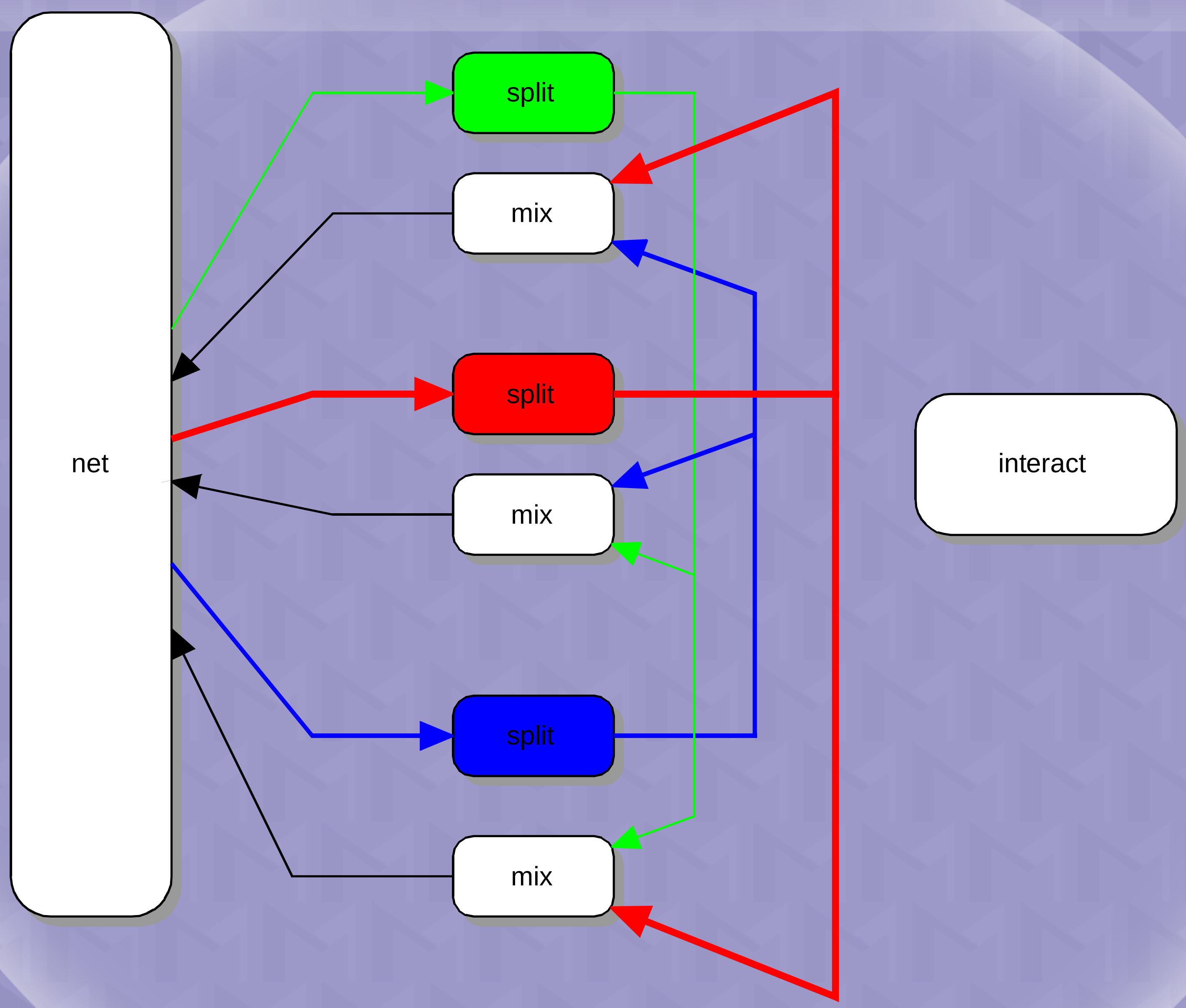

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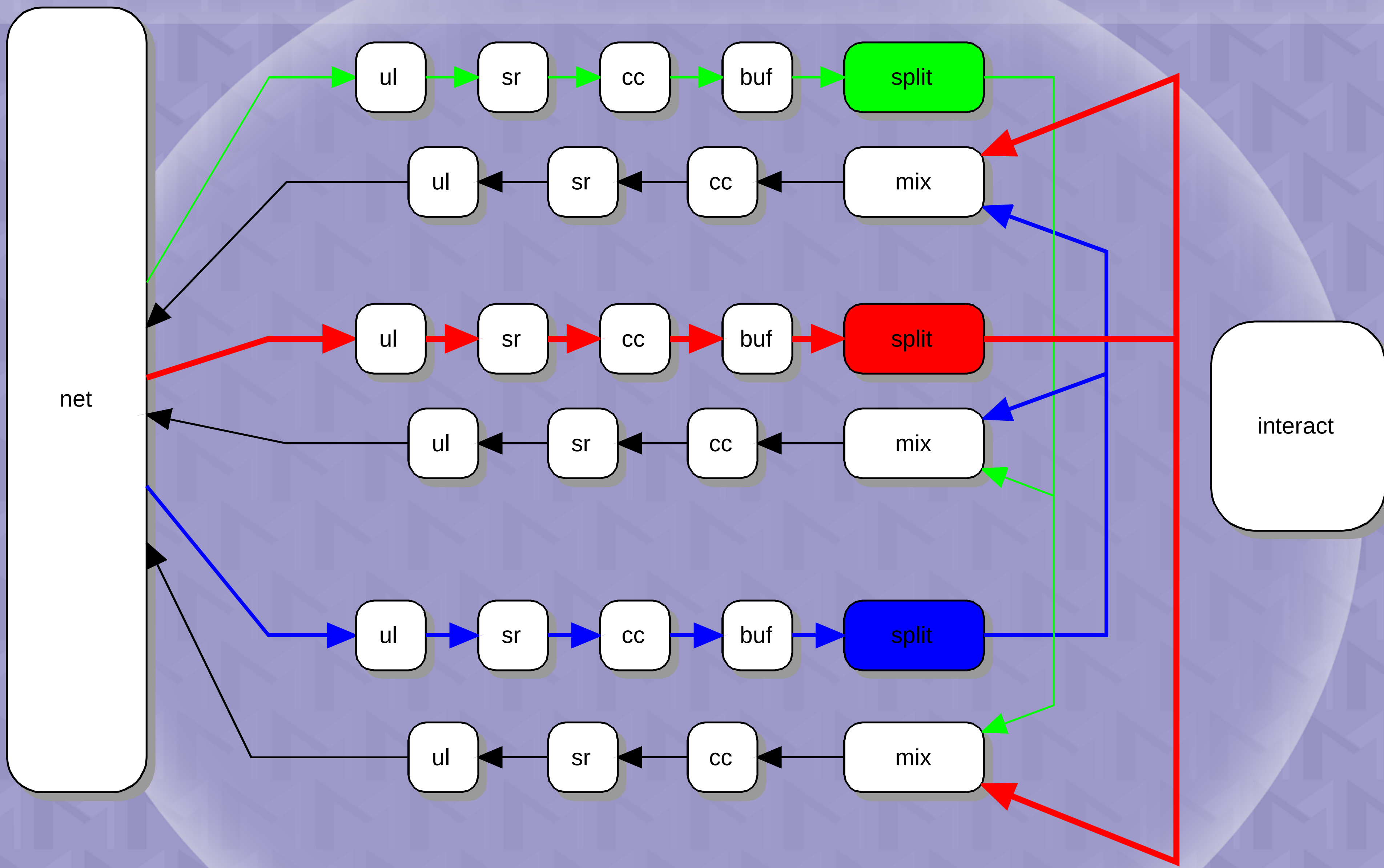


MAS Interfaces

for application and device programmers

- Application Programmer’s Interface (API)
- Device Programmer’s Interface (DPI)
- Device or device-class specific APIs

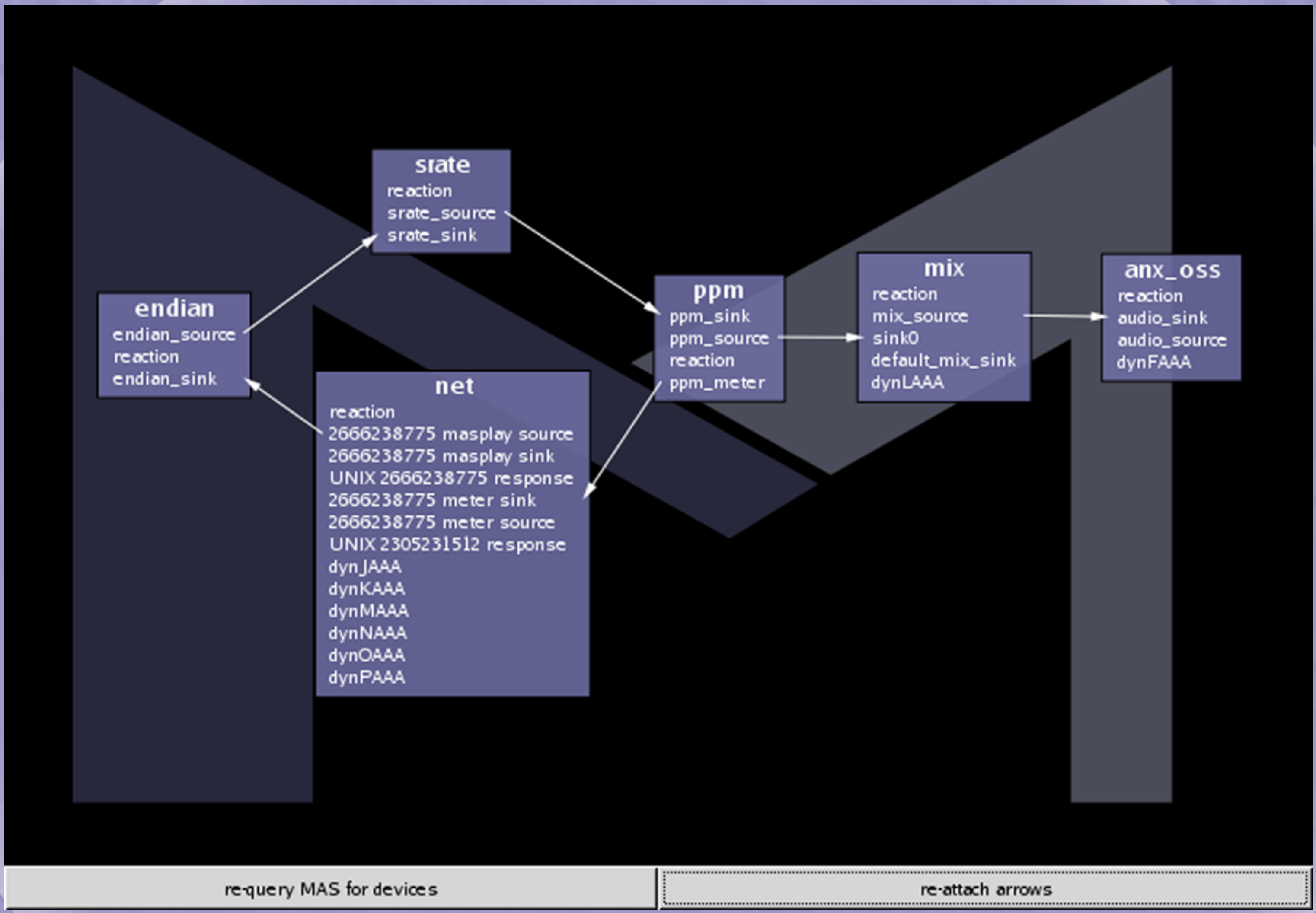
MAS Interfaces (continued)
for example

The MPEG 1 audio source device (mas_source_mp1a):

- Calls MAS DPI functions inside the server: *masd_post_data*, *masd_get_state*...
- Implements functions (actions) required by MAS: *mas_dev_init_instance*, *mas_dev_configure_port*...
- Implements MAS standard actions that are understood by the MAS API: *mas_get*, *mas_set*.
- Implements MAS device-class standard actions that are understood by the mas source device API: *mas_source_play*, *mas_source_stop*...

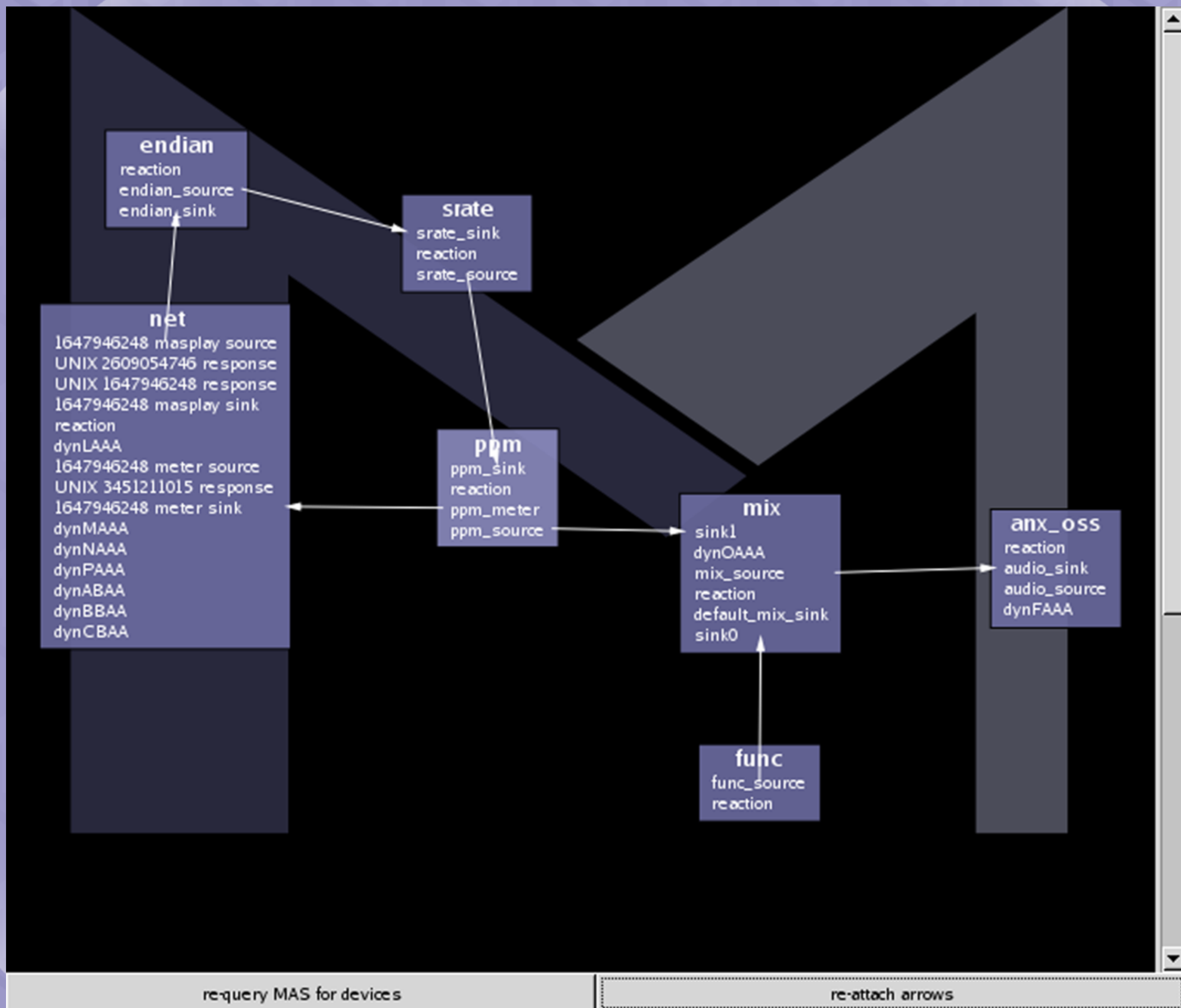
Metering Assemblage

peak program meter & sample rate converter



Two Application Assemblage

with a function generator



Security Concerns

- Open audio device for read/write
- File access: reading for streaming servers, writing for recording
- Real-time scheduling
- Trusted plug-in device signing
- TCP and UDP networking concerns
- The usual string problems

MAS Protocol Tunneling
Avoiding New Problems

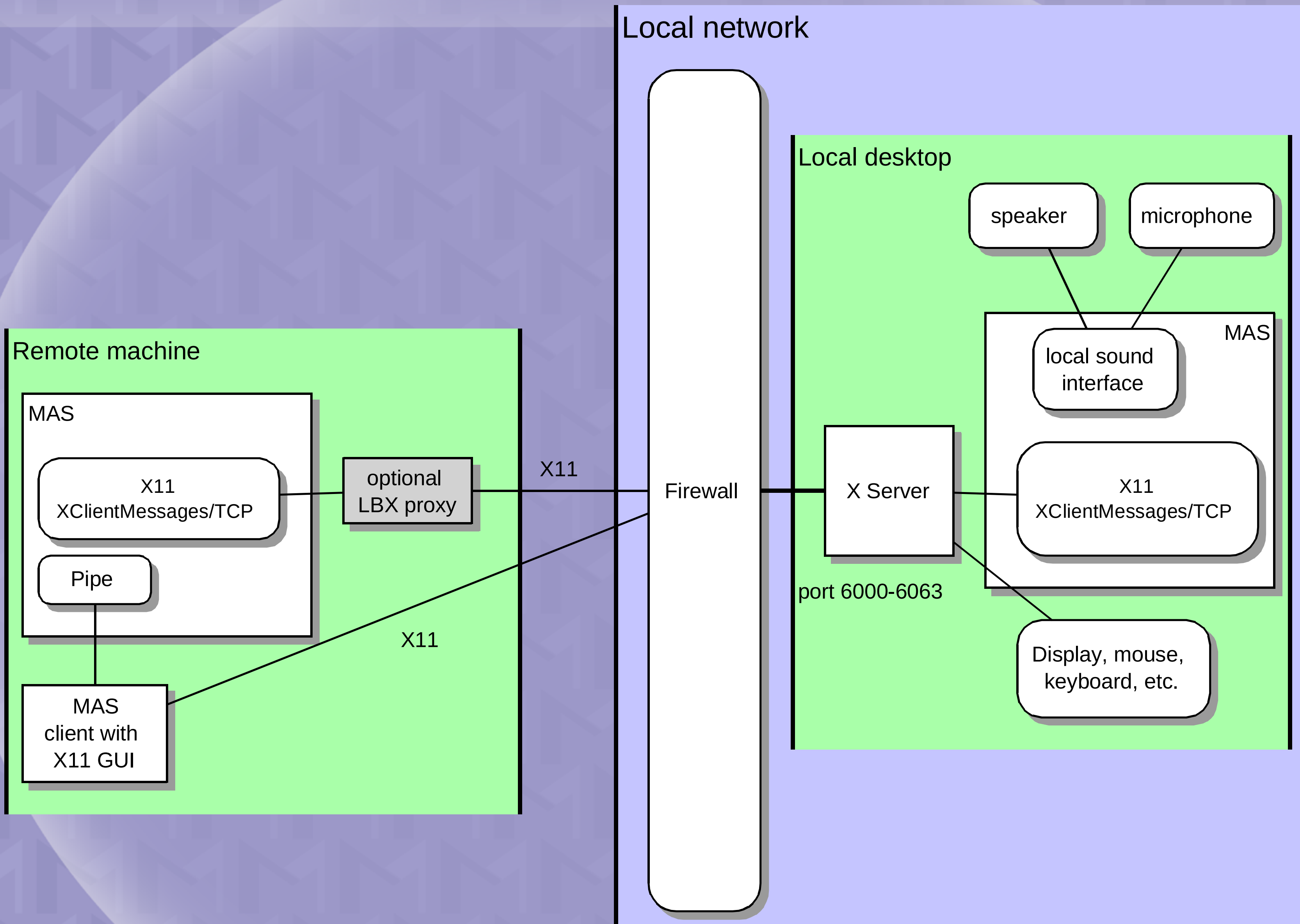
"X works, but I don't get any sound!"

- The user's X11 client and server are on opposite sides of a firewall.
- The user's X11 TCP/IP connection is tunneled through a secure shell connection.
- The user's X11 TCP/IP connection is proxied with LBX.

MAS Protocol Tunneling
Solution

- Extensible connection fallback mechanism.
- If X11 is present, MAS can use XClientMessages to proxy some control information using the X server.
- The MX extension will allow the X server to proxy more data for MAS.
- Best case: TCP control connection, UDP or TCP for media transport. Can be tunneled through SSH.
- Middle: using the MX extension to carry MAS protocol over X11/TCP.
- Worst: ClientMessages for control/media connection.

MAS Protocol Tunneling



The Development Process

- X.Org is partially supporting our work on the X11 tunneling mechanism and some other parts of our development effort.
- X.Org has played a fundamental role in the development of the MAS standard.
- Sun has independently supported several parts of our design and development effort.
- We’ve set up a project website and will be setting up a device registry and repository.
- We’re continuing to develop the MAS core, devices, and applications.

Credits

Mike Andrews

Garrett Banuk

Kaleb Keithley

Denis Marcin

Silvio Neef

Brian O'Brien

Leon Shiman

Ruth Shiman-Hackett

and the X.Org Audio Task Force Members

We Will Discuss

- History and Requirements
- The MAS Architecture
- Accessibility
- The Real Time Protocol
- Plug-in Devices and Assemblages
- MAS/X11 Interoperability
- Benchmarks
- The Development Process
- The Release Timetable

This is a Project, not a Product

After many legal issues, it’s open!

The project website:

http://www.MediaApplicationServer.net/

Development mailing list:

mas-devel@alex.shiman.com