Real-Time Transport and Multicast: Emerging Internet Services and Research Issues

Henning Schulzrinne
AT&T Bell Laboratories (Murray Hill)
hgs@research.att.com

BL011352, BL011355, BL011385, BL011387

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Overview

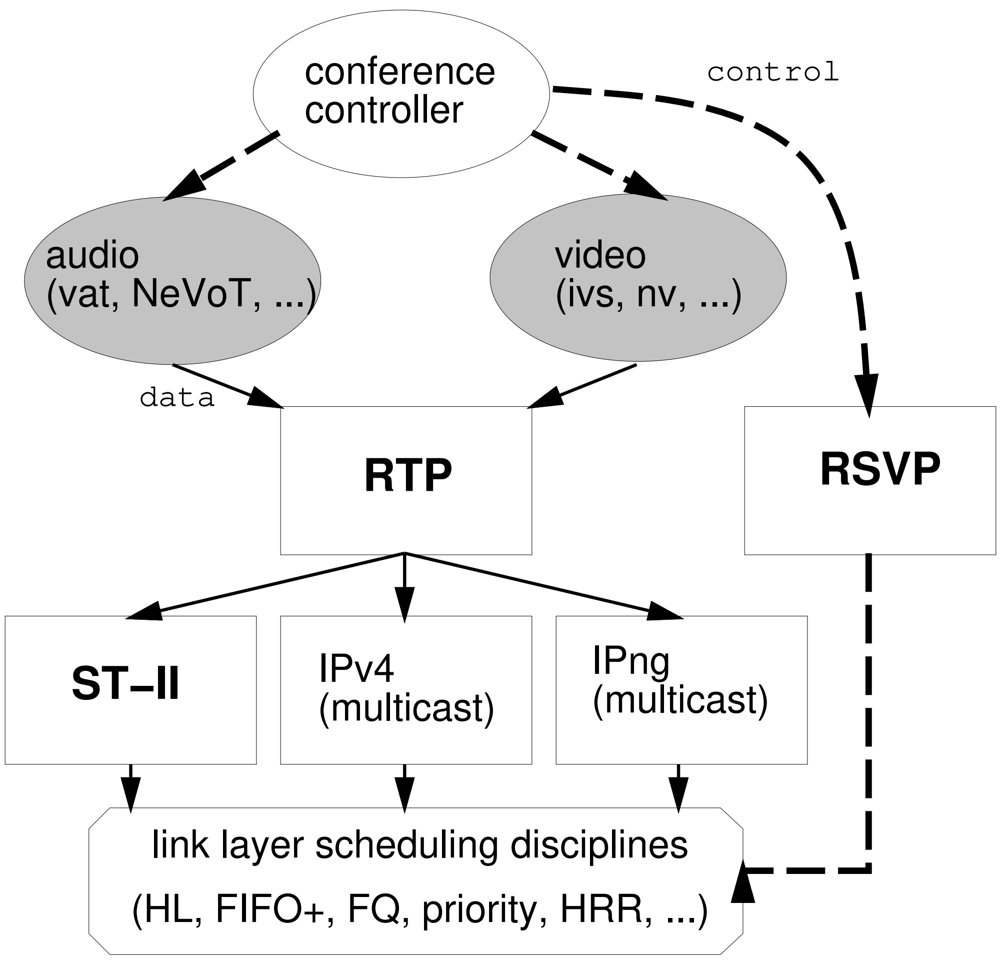
- applications and architecture
- resource allocation and reservation
- transport protocols
- conference control
- audio and video tools

Pieces of the Puzzle

a.k.a. “Signaling”:

1. flow specification: QOS requirements, source characteristics
2. QOS-sensitive routing: delay, loss, cost, ...
3. resource reservation: time, space
4. admission control (advance reservation)
5. non-FIFO packet scheduling

RT Service Architecture



Service Model

Current service model (Internet, X.25, . . .):

- point-to-point
- best effort
- datagram (or VCs)

New service models – not just Internet!

- point-to-multipoint (TV, lecture)
- multipoint-to-multipoint (conference)
- guaranteed quality of service
- predicted quality of service

RT Multimedia: Current Applications

- IETF since April 1992; March 1993 (Columbus):
  - several concurrent channels
  - audio (bidirectional) and video (outbound only)
  - 14 countries (AT, AU, CA, CS, DE, ES, FI, FR, KR, NL, NO, SE, UK, US)
  - 339 hosts
  - see CCR July 1992
- workshops, conferences, talks (Xerox PARC), ...
- Clinton/Gore speech at Silicon Graphics
- already 7% of backbone traffic

What's new?

Available: audio bridges; audio conferencing services, dedicated video conferencing systems (PictureTel etc.), ...

- large-scale multipoint (hundreds of sites)
- very dynamic membership ($\approx$ cable TV, not video conference)
- receiver-initiated
- low hardware investment (workstations), particularly receive-only
- wide-area non-RT networks
- multi-platform (Mac, PC, workstations, ...)

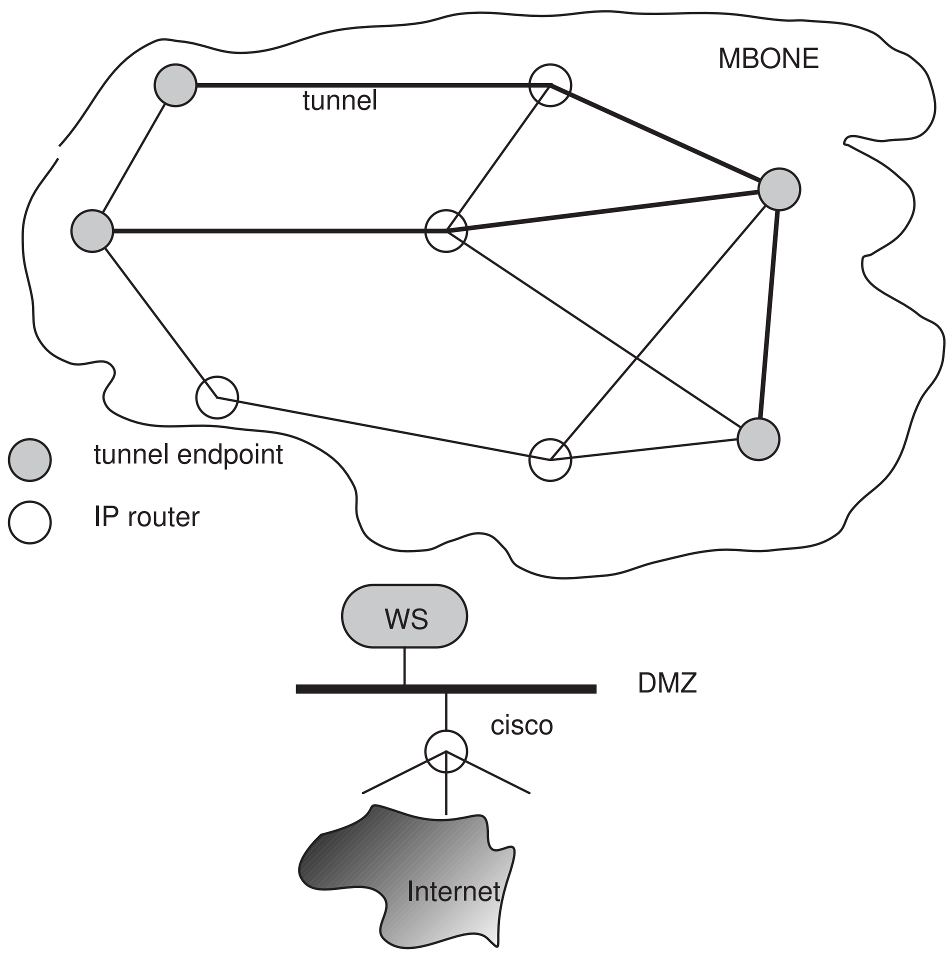
What's new?

- services:
  - speaker identification
  - privacy and security (authentication, encryption)
  - directory services
- media:
  - variable-bit-rate video
  - high-quality audio (stereo, CD-quality)

IP Multicast

- receiver initiated
- IP multicast: send to group identified by class-D address (224.0.0.0 to 239.255.255.255)
- "free" on Ethernet LAN (mapped into 01.00.5E.xx.xx.xx)
- group announcements via IGMP (like ICMP)
- gateways determine whether one or more members on local net
- source-based tree
- pruning based on thresholds and IP time-to-live
- available for SunOS, Ultrix; native in Solaris 2, Irix

MBONE


MBONE
tunnel
tunnel endpoint
IP router
WS
DMZ
cisco
Internet

MBONE

- virtual (overlay) network on physical Internet
- approximately 300 networks connected
- tunnels: IP loose source route option or IP-over-IP encapsulation
- XUnet connectivity exists, AT&T MBONE planned

Packet Scheduling

1. bounded delay jitter: Stop-and-Go, Fair Queueing $\rightarrow$ non-workconserving
2. guaranteed throughput: HRR, Virtual Clock
3. best effort, “need-based”: HL, FIFO+
4. best effort, “need-blind”: FIFO, LIFO

Strict guarantees $\Rightarrow$:

- lower system utilization
- worse circuit performance

Not every real-time application needs strict jitter bounds!

Flowspec

- ST-II (RFC 1190)
- Partridge (RFC 1363):
  - maximum transmission unit
  - token bucket rate, size
  - peak rate
  - minimum delay noticed; delay variation
  - loss sensitivity (rate, burst)
- application needs $\neq$ implementable by switch

ST-II

origin in 1979, revised in 1990

- similarities to ATM
- virtual circuit, but unreliable
- hop identifier swapping
- point-to-multipoint
- flow specification

RSVP

Zhang, Deering, Estrin, Shenker, Zappala (Xerox, USC)
goal: resource reservation ("state distribution"), not routing, resource control, admission control

Design goals:

- heterogeneous receivers (capability, willingness to pay)
- diverse resource needs (non-additive)
- allow receivers to switch channels
- adapt to routing changes
- control overhead: sublinear growth with participant count
- modular design (different technologies)

RSVP – Design Principles

- receiver-initiated reservation ($\rightarrow$ IP multicast)
- separating reservation (long term) from packet filtering (dynamic)
- providing different reservation styles:

  no filter: all sources in multicast group share reservation

  fixed filter: only some sources in mc group use reservation

  dynamic filter: receiver can change sources that use reservation ("channel surfing")
- maintaining "soft-state" in the network $\rightarrow$ periodic refresh, no explicit teardown

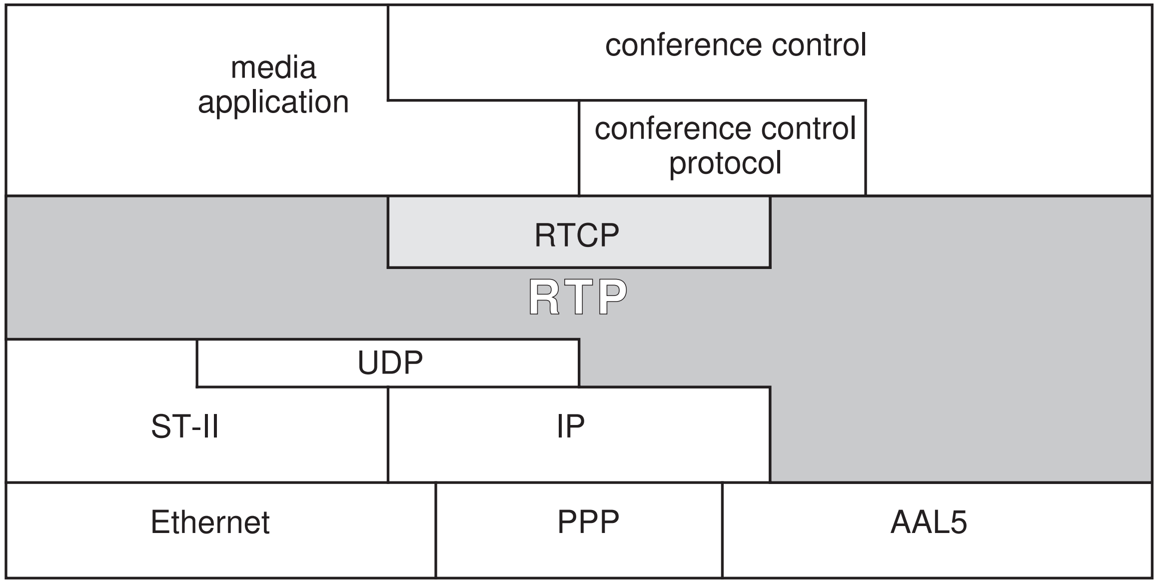
RSVP – Open Issues

- scaling: messages, switch state
- coexistence with routing
- recovery after switch, link failures
- set-up, dynamic switching delays

RTP Overview

RTP = transport (or session) services

- real-time applications (audio, video, simulation, control, . . .)
- unicast + multicast



submitted as proposed Internet standard

RTP Protocol Services

RTP: RT transport protocol (unidirectional):

- framing (if needed)
- identify synchronization source
- transfer media data (unreliably)
- demultiplexing (flows, e.g., combined audio and video)
- synchronization/sequencing (65536 Hz timestamp)
- next layer (e.g., media) identification

RTCP: control protocol (bidirectional):

- identify participants
- describe content
- quality-of-service information
- request for retransmission

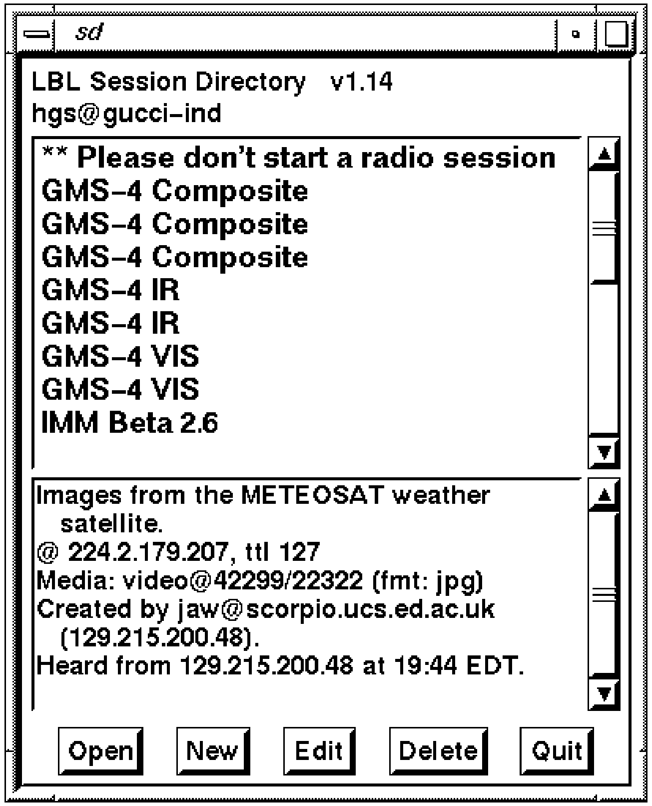
Software Sampler

`vat`	A	M	PD	Lawrence Berkeley	Sun, SGI, DEC
`nevot`	A	M	PD	AT&T BL	Sun, SGI
`nv`	V	M	PD	Xerox Parc	Sun
`CU-SeeMe`	V		PD	Cornell University	Mac
`PicWin`	V	M	C/PD	BBN	Sun
`ivs`	AV	M	PD	INRIA (H.261)	Sun, SGI, HP
`Communique!`	AV		C	InSoft	Sun (Parallax)
`PSVC`	AV		C	Paradise	Sun (Parallax)
`DECspin`	AV		C	Digital Equipment	DEC, (Sun)
`wb`	W	M	PD	Lawrence Berkeley	Sun, SGI

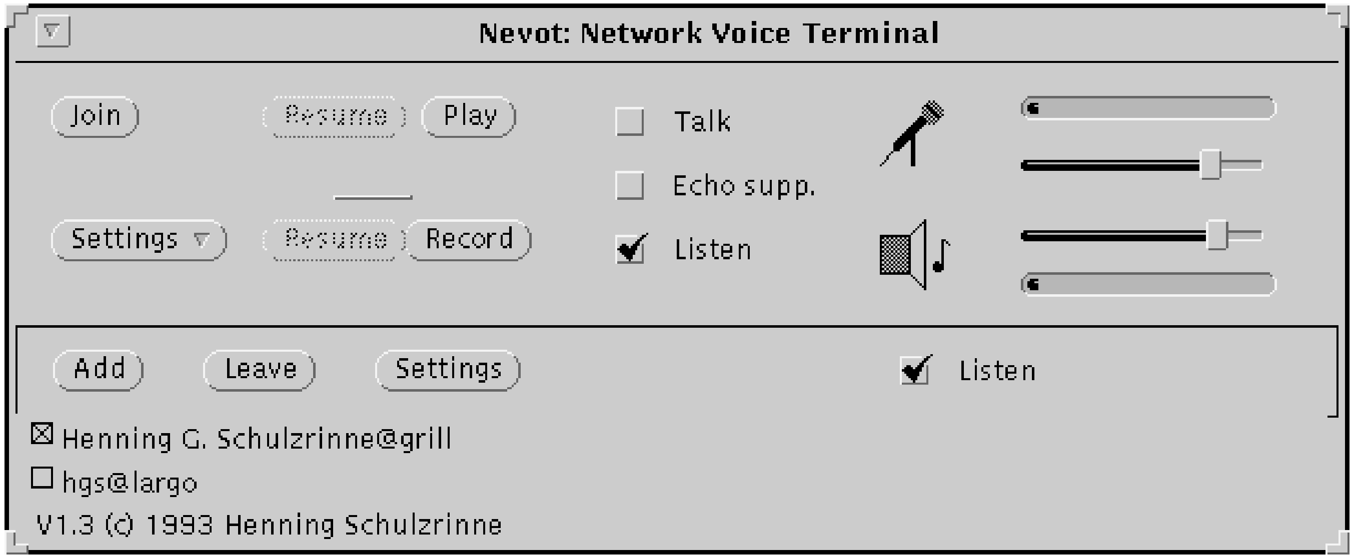
A: audio, V: video, W: whiteboard; M: multicast; C: commercial; PD: "free"

sd: Session Directory

list available MBONE "services":



NeVoT: Network Voice Terminal



several transport protocols

- IP/UDP unicast and multicast
- IP/TCP
- ST-II

NeVoT

- multiple simultaneous conferences
- software encodings: 16-bit linear PCM, μ/A-law PCM, ADPCM (G.721, G.723, DVI), GSM (13 kb/s), LPC (4 kb/s)
- testbed for investigation of playout mechanisms, loss recovery, control mechanisms
- implemented as Xview application on Sun, SGI, DEC workstations

Conference Control

currently, “loose” control:

- suitable for large ($10^1 \ldots 10^3$), open conferences with very dynamic participation
- no central agents
- advertise sessions via multicast (sd, LBL) at well-known address
- conflict resolution via scope-based assignment
- periodic announcement of participants' identification
- announcement period adaptive to scope and participant count

Conference Control

need "tight" control:

- end-to-end control, not network resources
- explicit parameter negotiation
- explicit admission control
- support for privacy (key distribution, etc.)
- mmusic WG at IETF
- interface to resource reservation

Major Open Problems

- network resource allocation (RSVP, ST-II, ...)
- scalable multicast
- QOS-oriented network management (under construction)
- conference control
- echo cancellation/suppression
- inter-media synchronization
- security for large, dynamic groups
- charging models (dynamic)
- reliable multicast