Media-on-Demand Services in the Internet

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Overview

- applications
- Internet integrated services architecture
- real-time transport: RTP
- Internet “cable television”
- multimedia control: RTSP
- synchronization meta files
- Internet access
- open issues

Applications

Internet Integrated Services Applications

- email, WWW, chat: not very time/throughput sensitive
- integrate ➠ single delivery mechanism:
  - telephony, conferencing
  - radio
  - cable television
  - video/audio-on-demand (ITV, done right. . .)

Internet Telephony/Radio/TV Features

- adaptive compression: trade $ for quality
- flexible source identification ("caller id")
- easier computer-telephony integration
- easy integration with email, WWW

Internet Radio

- 12,140 U.S. AM and FM radio stations, only 100 in Germany
- FM quality (56 kb/s) ➠ backbone capacity of 680 Mb/s
- New York City: 45 FM stations ➠ 2.5 Mb/s
- DirecTV: 31 audio channels ➠ 1.7 Mb/s
- easy time-shifting, content-labeling ➠ near media-on-demand

Internet Integrated Services Architecture

Internet Integrated Services Architecture

link-level: scheduling, link-layer-specific

IP multicast: trade-off state vs. tree optimality

reservation: set up scheduling state

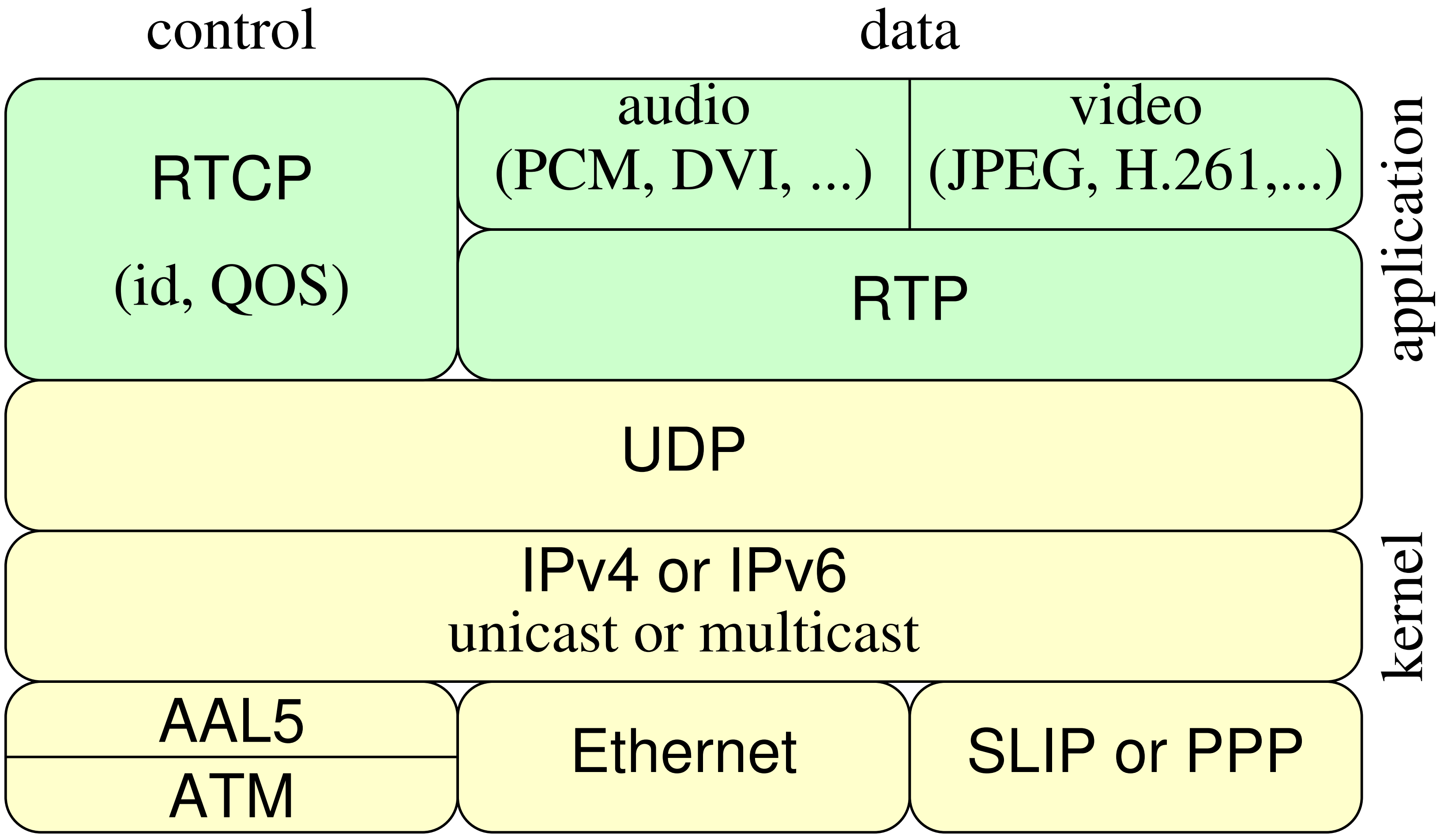
transport: timing, QOS feedback

applications: playout delay adjustment, error concealment, bit-rate adaptation, . . .

Internet Integrated Services Architecture

- philosophy: work both with and without resource reservation ➠ robustness
- most traffic remains best-effort ➠ reservation efficiency not too important
- few guaranteed service classes:
  - guaranteed load = “lightly loaded network”
  - guaranteed delay = Parekh-Gallagher bound, WFQ

Internet Multimedia Data Stack



+ RSVP (or TOS/precedence) when needed for differential service

RSVP Problems

- if reservation/tear down request lost, no immediate feedback
- can increase reservation latency or “phone off hook”
- large number of refreshes ➠ scaling problems
- hop-by-hop confirmation ➠ extend refresh interval

Real-Time Transport Protocol

RTP

Data:

- end-to-end transport of streams with timing information
- labeling: source (independent of network source), payload type
- encryption, sequencing, loss detection, ...

Control = RTCP ➠ periodic ($T = f(N)$) reports to multicast group:

- member names:
  - member list
  - loop detection
  - multiple media $\rightarrow$ single conference
- sender reports ➠ rate estimation, lip-sync
- receiver reports ➠ loss, jitter, delay feedback

RTP Scaling

RTCP Algorithm

- RTCP packets sent periodically
- in $[1.25\text{s}, 3.75\text{s}]$ after joining
- media bandwidth b, RTCP packet size p, session size N
- period

$$T = \max(5\text{s}, \frac{pN}{0.05b \cdot 0.75})$$

- compute $\rightarrow$ set timer $\xrightarrow{T}$ send
- randomized $[0.5, 1.5] \leftrightarrow$ packet synchronization

RTCP Scaling Problems

works fine for high-speed networks, smaller groups ($<$ 1000)

initial transient: lots join at the same time: “movie at ten”, channel surfing ➠ flooding, announcements lost

state storage: each receiver stores whole receiver list

slow estimate: learn only $\leq 1/\mathrm{s}$ for 28.8 kb/s

QOS transients: can’t distinguish 50% loss, 1 minute vs. 5%, 10 minutes

multicast: DVMRP prune timeout ➠ RTCP packets flooded everywhere

BYE: everybody leaves at once

RTCP Transient Suppression

Conditional reconsideration: if N at send instant $>$ N at timer computation, recompute T and check interval

Unconditional reconsideration: recompute even if N hasn't increased

SendMax: accelerate convergence for new members ➠

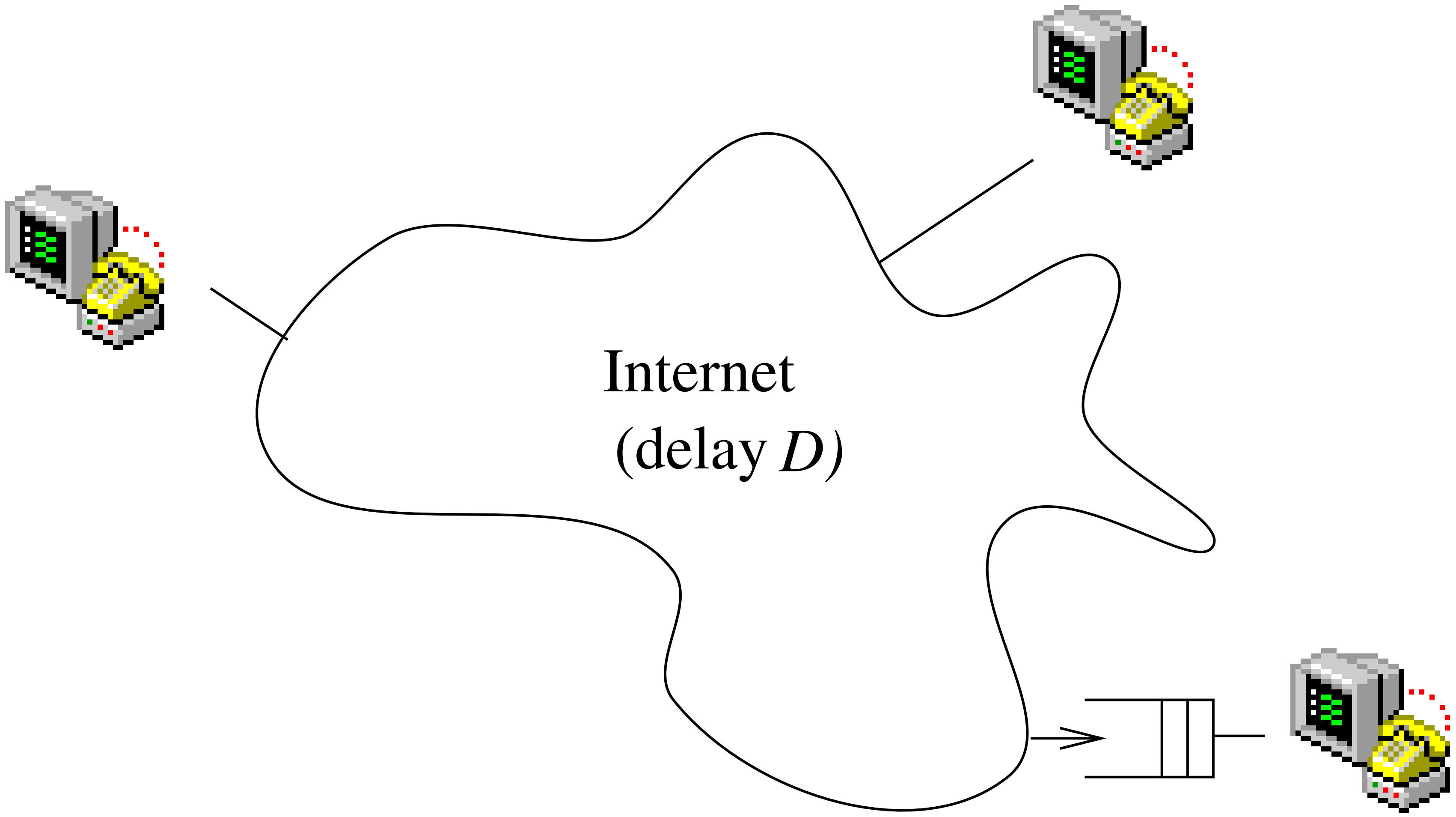
- send in RTCP packet: observed number of users
- compute interval $T = f(\max(\text{observed}, \text{allannounced}))$
- must track announcement for each member

Characteristics:

Learning curve: $L(t)$ = estimate at each member

Packets sent: ideally (no loss): = $L(t)$

Reconsideration: Network Model

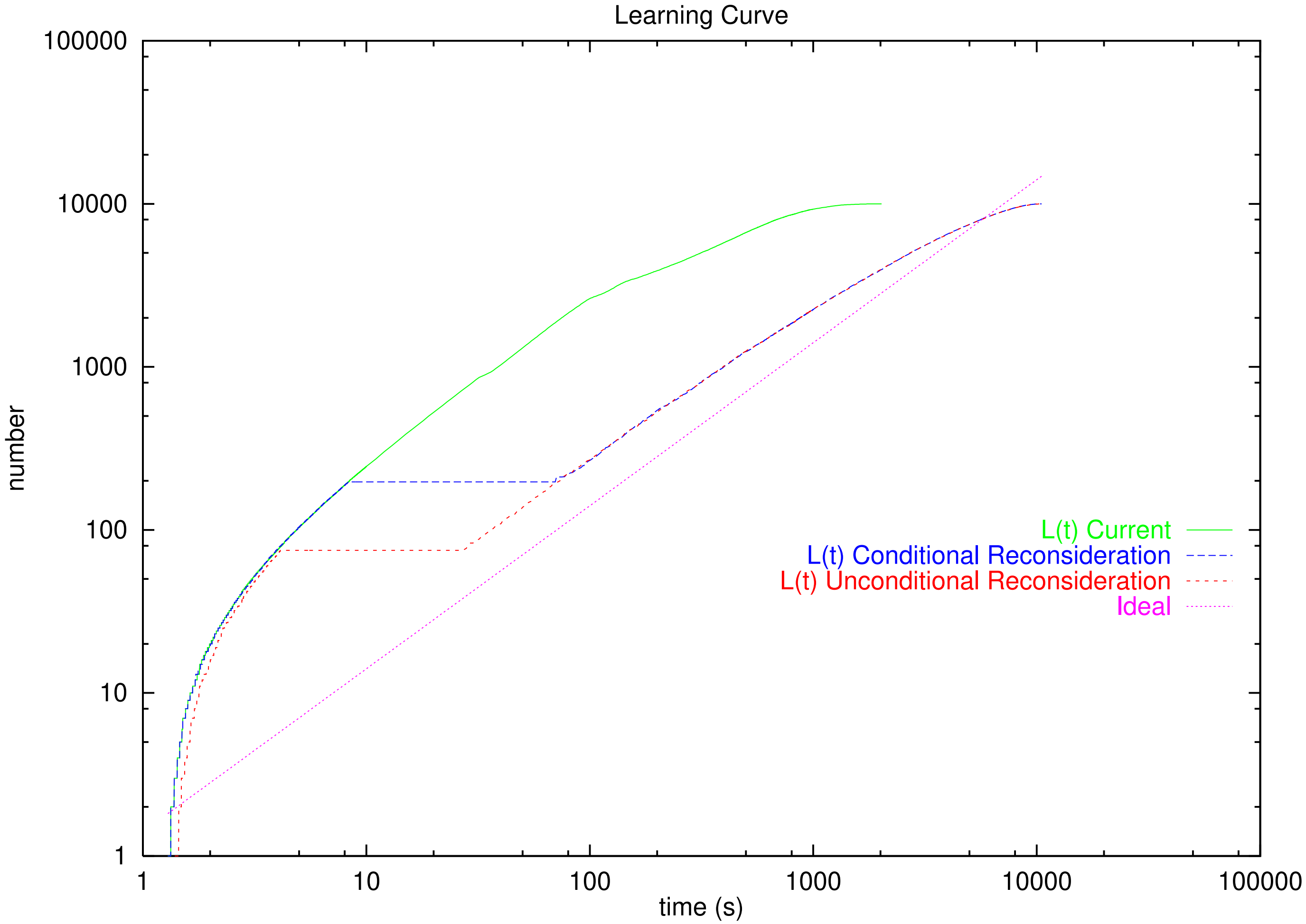


Reconsideration: Experiments

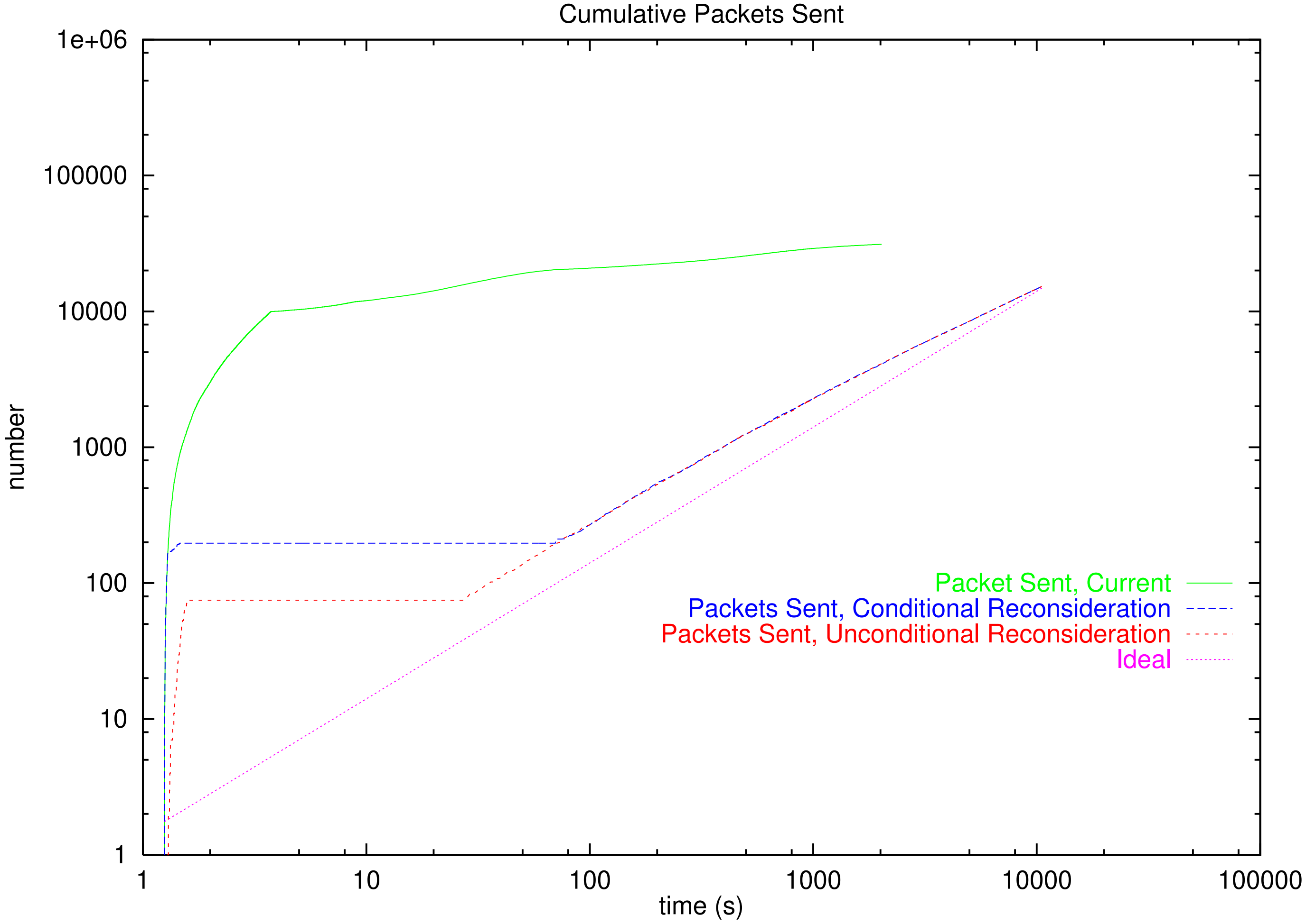
- 10,000 modem (28.8 kb/s) users in group
- join at $t = 0$ or 200 users every 200 ms
- 300 ms average delay, uniformly on [0 ms, 600 ms]
- 100 kB network buffer
- 128 byte RTCP packets

Note: backwards-compatible with existing spec

Reconsideration: Step Join



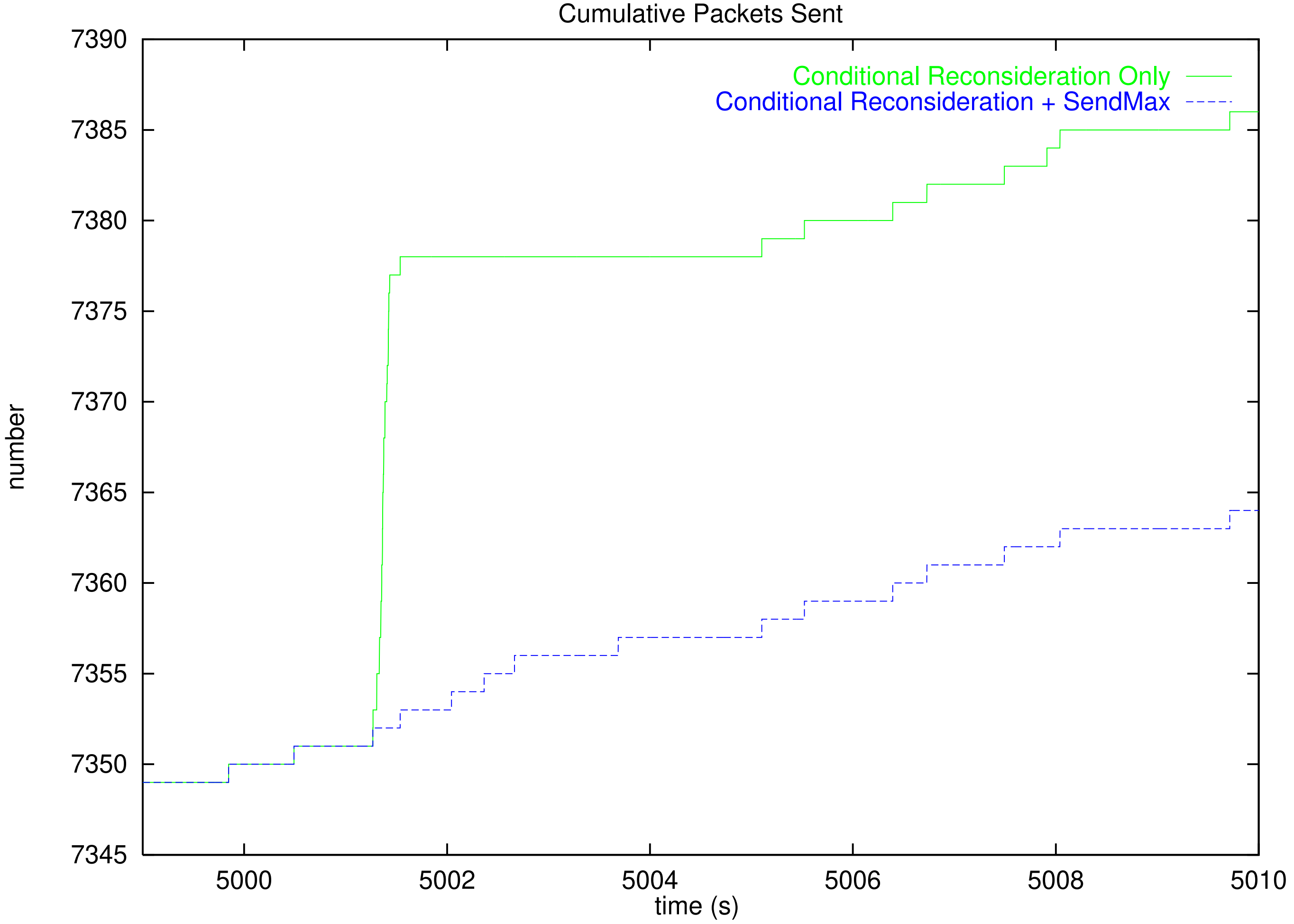
Reconsideration: Step Join



delay ➠ worse; slight dependence on distribution

Reconsideration: Linear Join

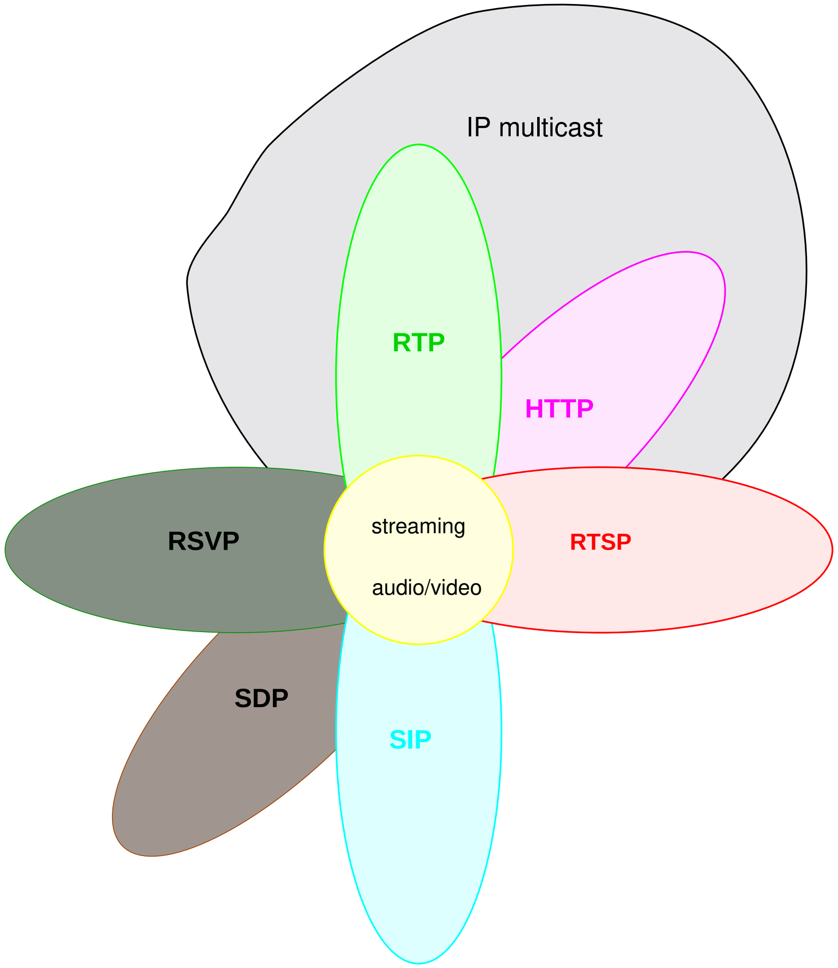
$t = 0$: +5000, $t = 5000$: +5000



RTSP – Real-Time Stream Protocol

- current IETF MMUSIC effort
- developed with Netscape and Progressive Networks
- complementary to SIP (telephony/conference signaling)
- http://www.cs.columbia.edu/ hgs/rtsp

Streaming Multimedia



(similar functionality, much simpler than DSM-CC)

Media Synchronization

separate streams (rather than MPEG approach) ➠

- appropriate QOS for each stream (delay, throughput, leaky bucket)
- may combine into one (RSVP) *flow*
- separate (but coupled) tools for different media
- multicast flow separation
- separate servers: load balancing, copyright
- lip-sync (in stream) ➠
  - RTP timestamps in samples or MPEG time
  - RTP timestamp and corresponding NTP timestamp in sender reports

  ➠ applications share synchronization bus
- media object synchronization: start of clips

RTSP: Requirements

- caching of media streams ($\neq$ HTTP!)
- firewalls, proxies
- distributed (linear) editing
- live events with dynamic media sets
- device control: camera pan/tilt/zoom, encoding parameters, ...

Corba, DCOM?

- Internet protocol design: (almost) reuse HTTP = "Internet RPC" ➠ spec, code, server, security reuse
  ➠ low cost of entry

RTSP: Protocol

- carried in TCP or UDP (with own reliability)
- TCP connection $\neq$ RTSP association
- “passing around the remote”
- options: connection/stream, connection/command, UDP
- RTSP sessions by identifier
- supports any presentation description
- control “streams” (audio, video) and “presentation” (movie)

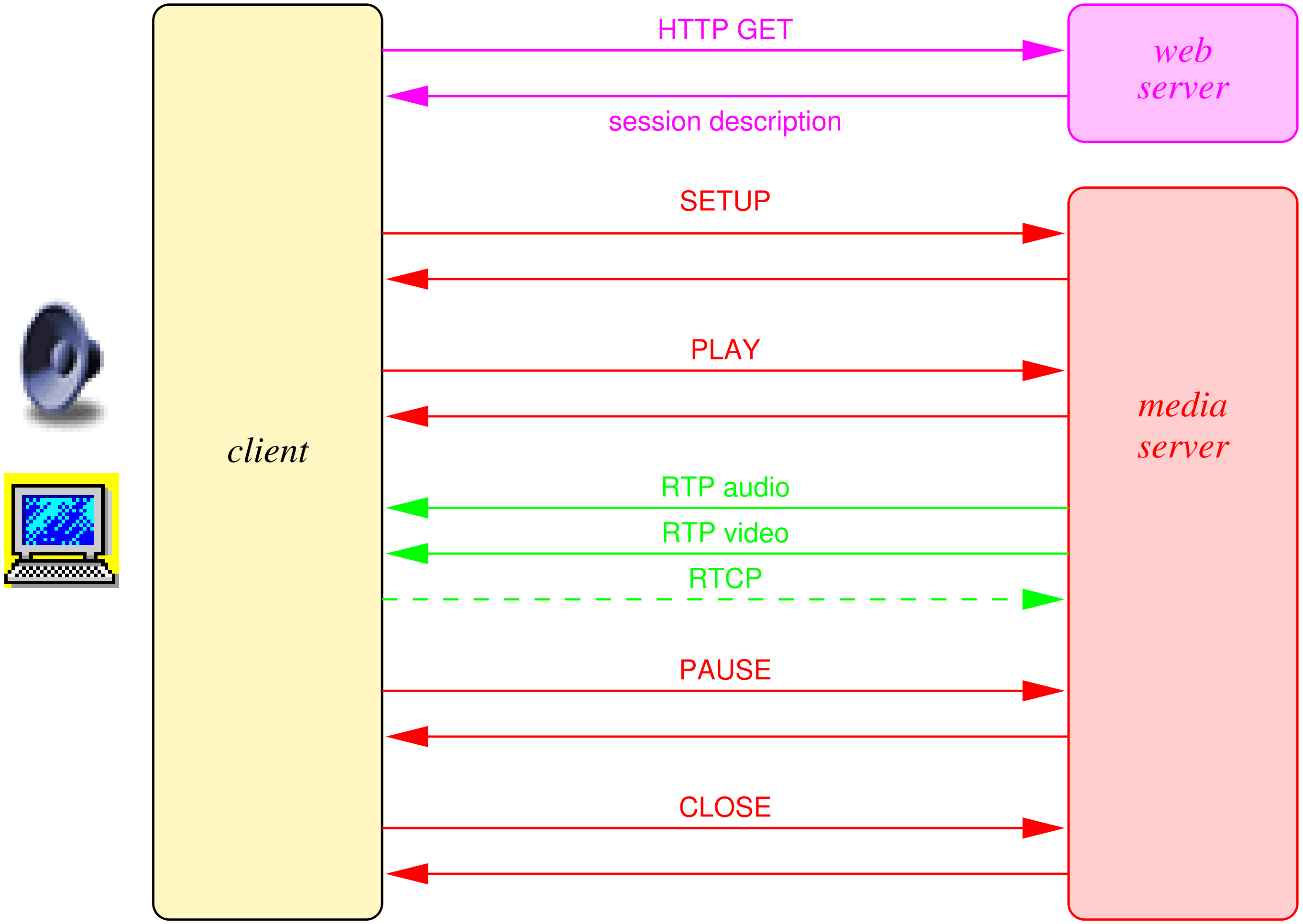
Web Integration

1. web page with "program guide"
2. contains pointer to presentation description (say, RTSL):

```
<session>
  <group>
    <track src="rtsp://audio.mtv.com/movie">
    <track src="rtsp://video.mtv.com/movie">
  </group>
</session>
```

3. RTSP sets up and controls delivery
4. RSVP reserves resources
5. RTP delivers data

RTSP Operation



RTSP Time

- normal play time (NPT): seconds, microseconds
- SMPTE timestamps
- absolute time (for live events)

allow absolute timing of events: ➠ “start playing movie at 10:05.34, at NPT = 10 s” ➠ synchronize distributed servers

- DSM-CC: single pending command
- RTSP: edit list (play 10-12, play 15-20, . . .) ➠ editing

Interaction with Conferencing

- want to integrate media playback into telephony, conferencing
- record conferences
- Internet receiver-initiated multicast ➠ just send to group

Near Video-on-Demand

- in wide area, *video*-on-demand not scalable
- near on-demand, with positioning, pause
- RTSP PLAY $t \rightarrow$ join appropriate multicast group for t
- easy in Internet: IP multicast groups ➠ no network signaling

Open Issues

- Internet architecture and infrastructure
- DAVIC vs. Internet: vertical (per-application) vs. universal IP
- reliability: “soft state” = robust, but not reliable
- charging and billing

Internet Access

Consumer Access

New services break \$19.95 flat-rate model:

- acceptable RT bandwidth = acceptable web bandwidth
- 200 concurrent users / T1 ➠ 7.5 kb/s
- currently: 10 customers/modem (AOL: 30) ➠ will decrease
- ➠ only 75c/month for pipe ISP → backbone
- ➠ “Internet radio” costs \$30/month for access

Daily Media Doses

media	minutes/day
long-distance calls, US	14
America Online (AOL)	32
local phone calls, US	38
total phone line usage	52
Internet	57
Television, Sweden	120
television, USA	240

Charging and Payments

- charging: multiple providers, multicast, congestion-based
- 800/888, 900 services
- model: flat rate for best effort, per-kb minute for reserved
- “business-class service”: TOS, priority with bulk contract
- RSVP: include payment authorization in RESV packet
- with RSVP, all receiving parties pay (not the same?)
- prevent kickback schemes?
- include billing authorization for particular PATH msg id?

Summary

- price, features ➠ Internet as ISN
- data + control
- second (last?) chance to design telecom networks
- media control and signaling closely related