Introduction to Multicast Security

Beyond SSL/TLS

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Overview

- Use cases
- Multicast Fundamentals
- Comparing security solutions
- Introduction to SRTP
- Group Key Exchange

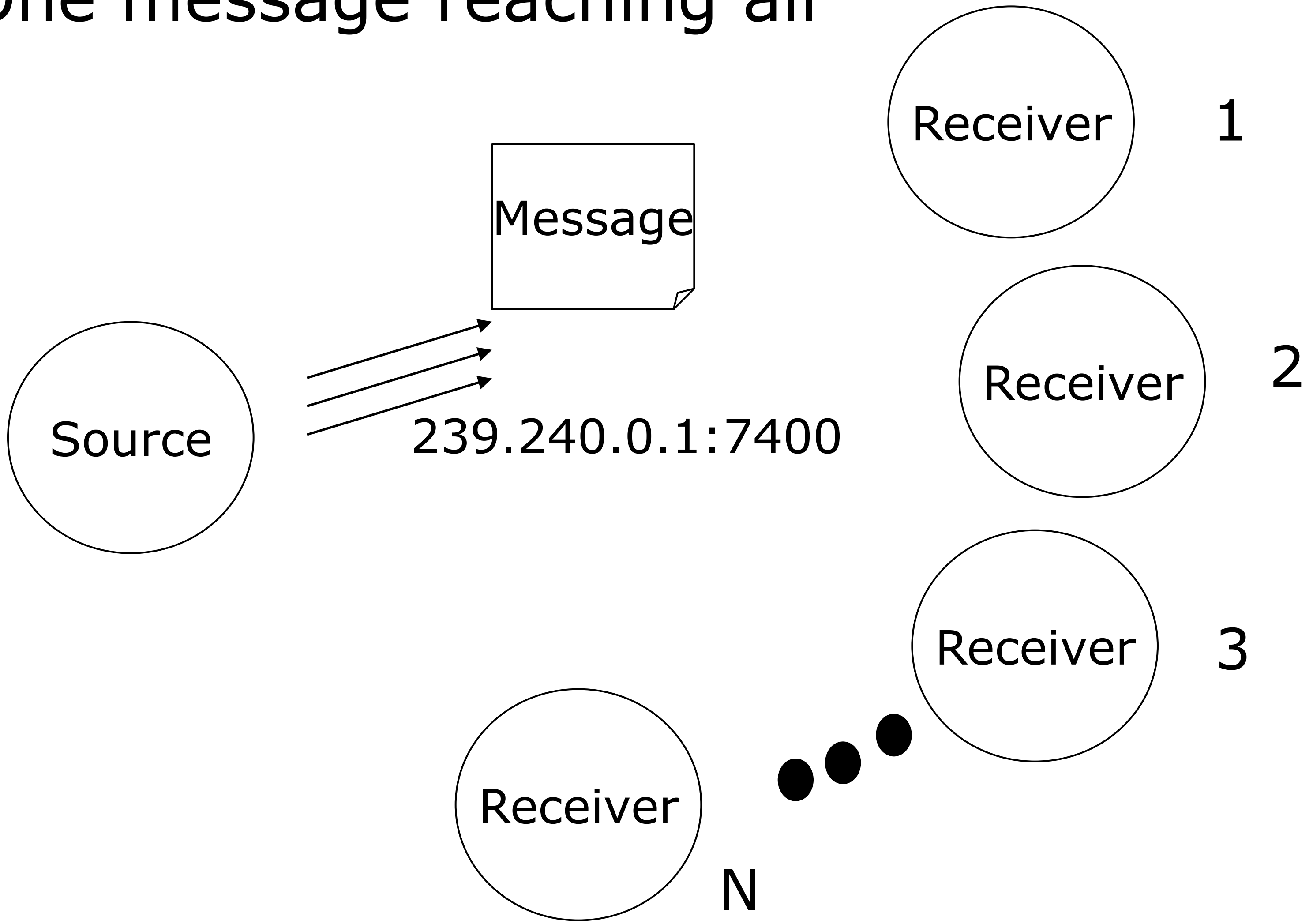
Multicast Transport Use Cases

Scaling, Fault-tolerant Distributed Apps

- Multi-participant multimedia conferences
- Replicated Databases/Filesystems
- Distributed simulation
- Active badge
- Control and measurement systems
- Event systems
- Data Distribution Services (DDS)

Multicast Transport Use Cases

- One message reaching all



Multicast for Data Distribution

Fault-tolerant Realtime Middleware

- DDS: Data Distribution Service for RT-Systems
  - Open OMG standard since 2004
  - Data Centric Publish/Subscribe, >1000 nodes
  - High volume of events/data
- Field of applications
  - Avionics
  - Automotive
  - Finance-IT
  - Public transport

Multicast Fundamentals

- UDP providing mulitcast functionality
- IPv4 multicast address:
  - Address range 224.0.0.0 to 239.255.255.255, eg 239.240.0.1
  - Requires Internet Group Management Protocol (IGMP)
- IPv6 multicast address:
  - Have the prefix ff00::/8 , eg: ff15::1
  - Requires Multicast Listener Discovery Protocol (MLD)

Multicast Fundamentals

- Listeners:
  - Binding to local address and port, eg 0.0.0.0:7400 and join a mcast group 239.240.0.1
  - Setsockopt: IP_ADD_MEMBERSHIP, IP_DROP_MEMBERSHIP
- Senders:
  - Binding to any address, any port
  - Setsockopt: IP_MULTICAST_LOOP, IP_MULTICAST_TTL, IP_MULTICAST_IF

http://www.linuxjunkies.org/html/Multicast-HOWTO.html

Multicast Fundamentals

Problem

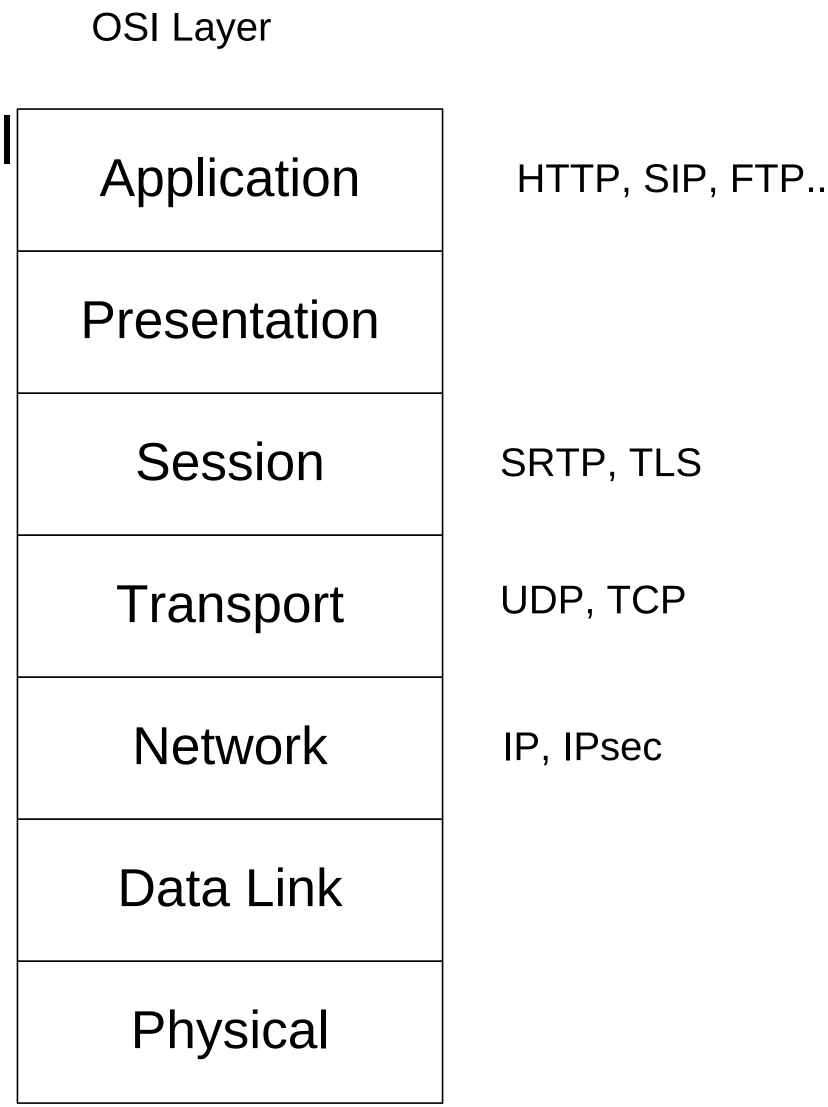
- Any node can join or leave a multicast group
- Any node can send multicast messages

Requirements

- Authentication
- Confidentiality
- Integrity
- Non-repudiation

Present Transport and Network Security

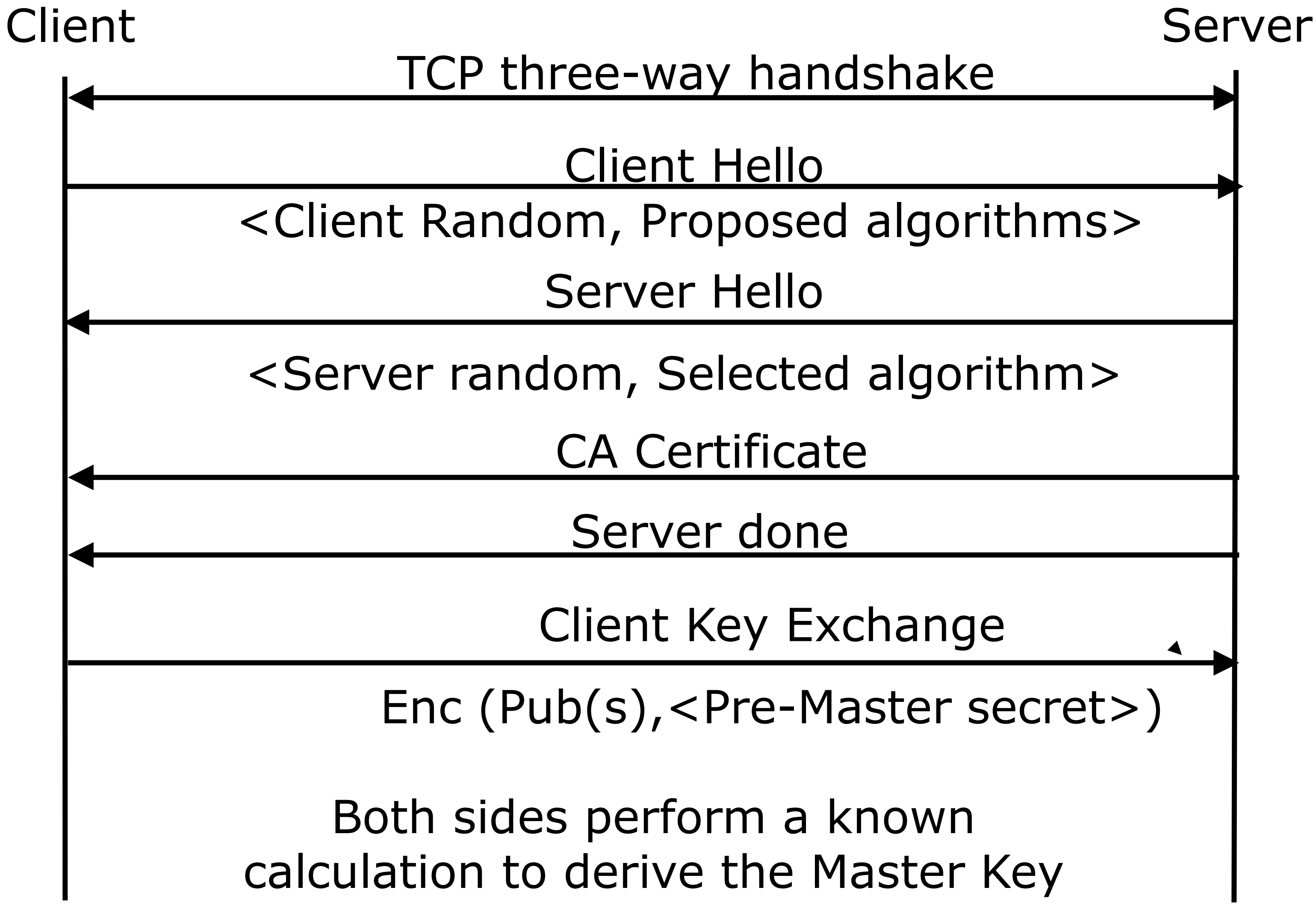
- SRTP: Secure Real Time Protocol
  - Protects RTP over UDP
  - Support for Multicast
- TLS: Transport Layer Security
  - Popular for Email, web, etc.
  - Usually over TCP, but also UDP
  - No support for multicast
- IPsec: network security protocol
  - Multicasting not supported
  - Layer 3, host2host



Why does SSL/TLS not match

- 1:1 / client-server oriented
- In-Band/blocking Key-Exchange/Handshake
  - On re-keying critical interruption of data flow
- Connection-/Stream-oriented
  - Not robust against packet loss
- Variation: Datagram-TLS (RFC4347)
  - Robust against packet loss (except handshake phase)
  - Handshake phase requires reliable transport
  - still 1:1

SSL/TLS Handshake



Requirements for Alternatives

- 1:N communication pattern (eg. UDP-Multicast)
- Skaling
- Non-blocking Key-exchange
  - 1) Out-of-band   or 2) using separate signaling channel
- Robust against packet loss
- Auth. & Confidentiality & Integrity
- Optional: Robust against replay

- Possible Solutions: SRTP and IPsec

Alternative: Ipsec (Network Layer)

- Network layer/host2host
- Out-Of-band key-exchange (IKE)
- Cisco: GRE (Generic Route Encapsulation) tunnels
  - Tunneling Mcast messages thru Ipsec tunnel
  - Each tunnel is encrypted seperately
- Requires full mesh
- Not scaling
- Requires administrative rights to configure IPsec

S-RTP as Alternative

- Underlying RTP/RTCP: Unicast & Multicast
  Packet oriented multimedia protocol
- Protection fine grained: application/user/port
- Session oriented
- Out-Of-band key-exchange
  - Application/use-case specific
- Protecting Auth & Confidentiality & Integrity
- Optional: Protects against reply attacks
- Can be configured on application layer
  - no admin rights

RTP – Use Scenarios

- Primarly for multi- participant multimedia conferences

But also suitable for

- Storage of continuous data
- Interactive distributed simulation
- Active badge
- Control and measurement

RTP – Real Time Protocol

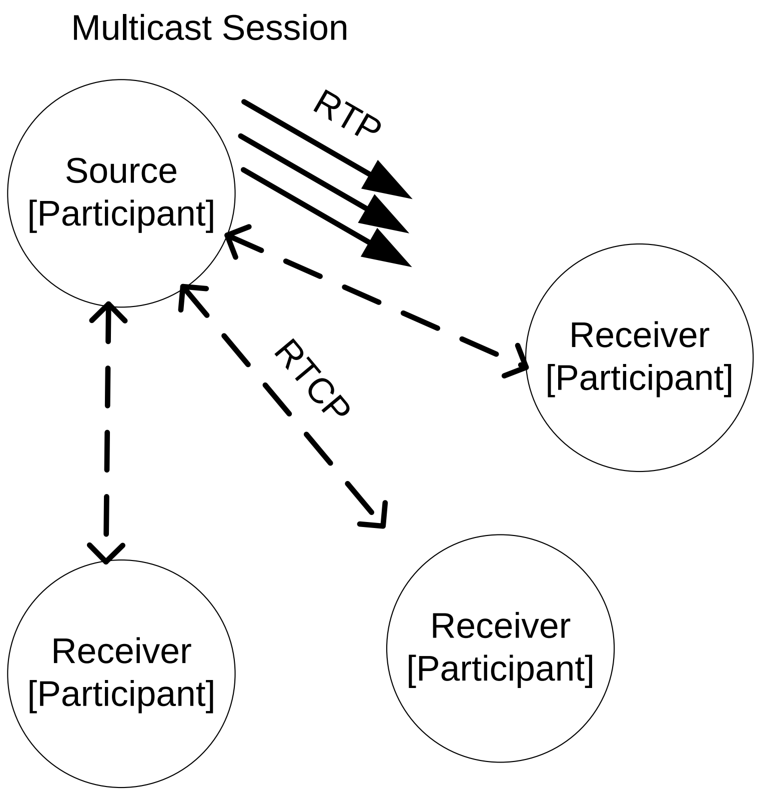
- RFC-3550 in 2003
- Suitable for appl. transmitting real time data end2end
  - audio, video or simulation data,
  - over multicast or unicast network services
- Over unreliable transport (UDP)
  - Packet loss
  - Re-ordering
- Augmented by a control protocol (RTCP) to allow
  - Monitoring of the data delivery in a manner scalable to large multicast networks,
  - To provide minimal control and identification functionality.
- RTP and RTCP designed to be independent of the underlying transport and network layers.

RTP/RTCP

- RTP: to carry data that has real-time properties.
- RTP control protocol (RTCP): to monitor the quality of service and to convey information about the participants in an on-going session.

RTP Communication

- RTP provides
  - payload type identification
  - sequence numbering
  - timestamping
  - delivery monitoring
- RTP supports multicast distribution if provided by the underlying network

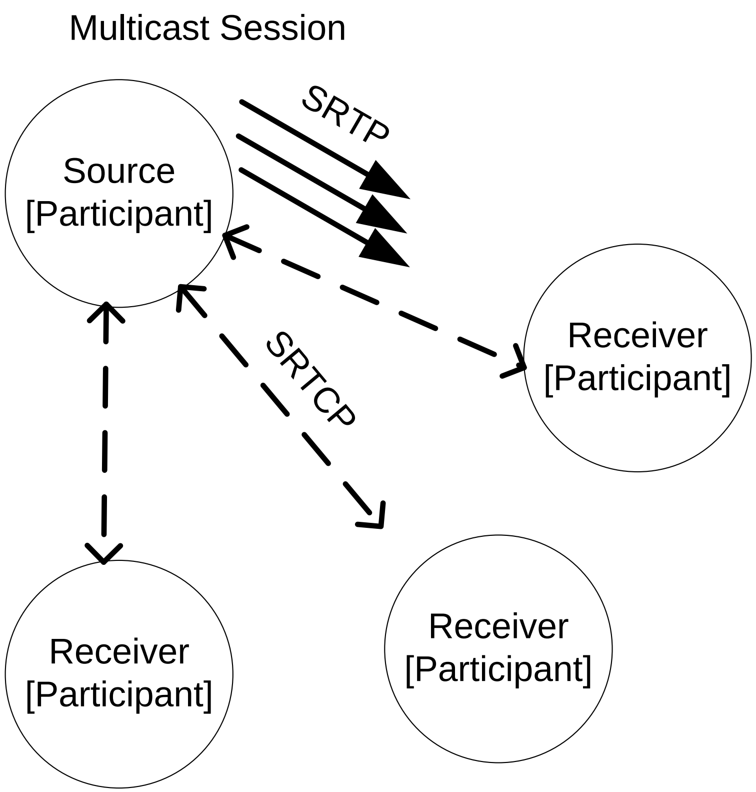


RTP Message

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|V=2|P|X|  CC   |M|     PT      |       sequence number         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           timestamp                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           synchronization source (SSRC) identifier            |
+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
|            contributing source (CSRC) identifiers             |
|                             ....                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          payload  ...                         |
|                               +-------------------------------+
|                               | RTP padding   | RTP pad count |
+>+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Secure RTP Communication

- RFC-3711 in 2004
- Symmetric ciphers (AES, etc.)
- Using stream-ciphers
  - calculation parallelizable
  - pre-calculation possible
  - AES counter mode (CTR)
  - AES Counter with CBC-MAC (CCM)
- Robust against packet loss
- No key in-band exchange as with TLS

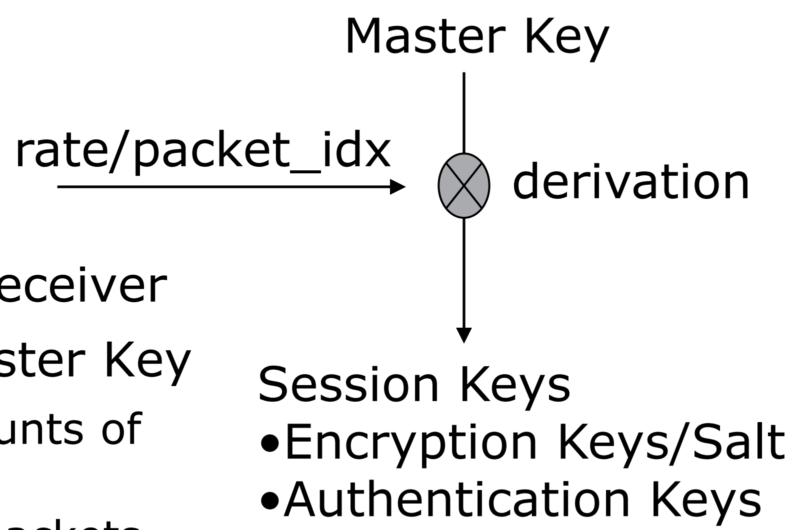


Secure RTP Message

```
        0                   1                   2                   3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<+
     |V=2|P|X|  CC   |M|     PT      |       sequence number         | |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |
     |                           timestamp                           | |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |
     |           synchronization source (SSRC) identifier            | |
     +=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+ |
     |            contributing source (CSRC) identifiers             | |
     |                               ....                            | |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |
     |                   RTP extension (OPTIONAL)                    | |
   +>+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |
   | |                          payload  ...                         | |
   | |                               +-------------------------------+ |
   | |                               | RTP padding   | RTP pad count | |
   +>+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+<+
   | ~                     SRTP MKI (OPTIONAL)                       ~ |
   | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |
   | :                 authentication tag (RECOMMENDED)              : |
   | +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |
   |                                                                   |
   +- Encrypted Portion*                      Authenticated Portion ---+
```

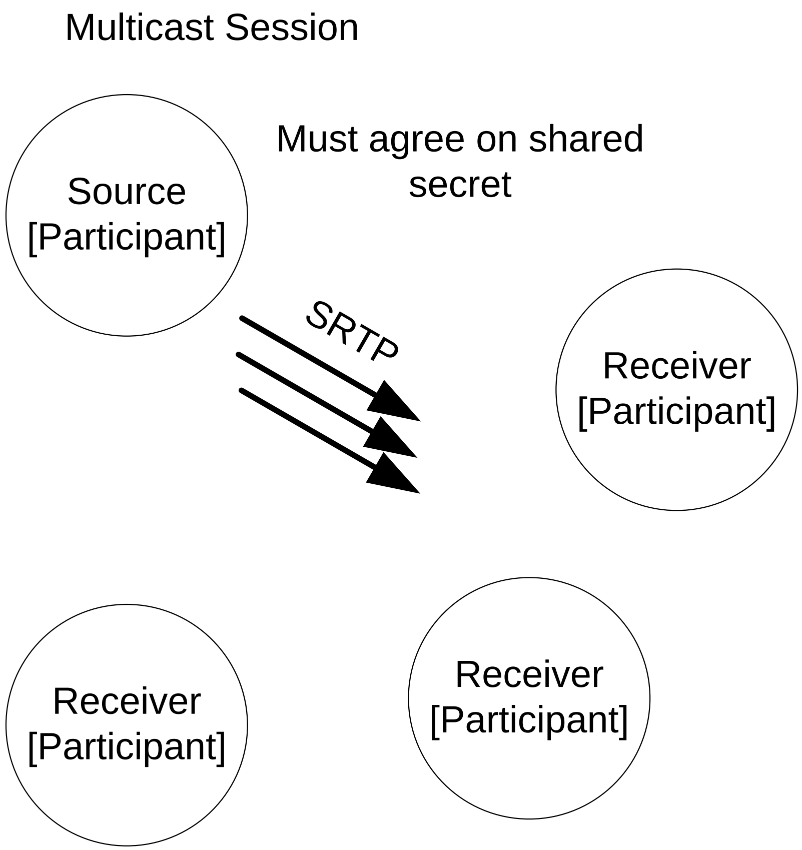
Secure RTP/RTCP Overview

- SRTP Provides Protection
  - Replay protection (windowing)
  - Confidentiality (AES)
  - Authentication/Integrity (HMAC-SHA1)
- Cryptographic Context formed by sender + receiver
- Key Derivation: Session keys from single Master Key
  - Preventing attacker from collecting large amounts of cipher text with one singe session key
  - Derivation rate in relation to number of sent packets
- Short commings:
  - Sequence counter only 16bit: Synced roll-over counter required – out-of-band or optional message attribute
  - Little documentation regarding Key Exchange for multicast sessions
- Implementation: libSRTP (C language)
  - BSD-based license



Group Key-Exchange

- SRTP relies on an external key management protocol to set up
  - Initial master key
  - Initial sequence number
  - Current roll-over-counter (ROC)
- Key exchange should scale and be robust
- No standard Key-Exchanges:
  - ZRTP (in-band, 1:1, DH)
  - EKT:Encrypted Key Transport for Secure RTP (in-band, decentralized, key-encr.cipher AES)
  - SIP/SDES (off-band, overhead)
  - MIKEY (various modes)
    - RSA-R: reverse RSA



Mcast Challenges

- Not all devices or interfaces support Multicast
  - Most Android devices do not support Mcast (2010)
  - Some network-interfaces configured without Mcast
  - Works within LAN, but limited in WAN cross routers
- Slightly differences per OS (Windows vs Linux)
- Routing of Mcast traffic
  - Default network-interface for Mcast messages
  - Multi-homed hosts require out-bound Mcast socket per NIC with explicit routing settings

Group Key-Exchange: Mikey

MIKEY: Multimedia Internet Keying Protocol [RFC3830]

Modes:

- Pre-shared key mode (PSK),
- Public-key (RSA) mode,
- Diffie-Hellman exchange (DHE) mode.

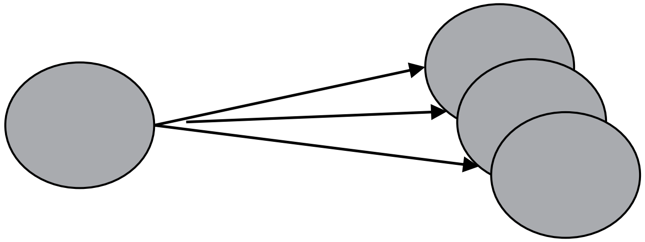
Primary motivation of protocol design

- low-latency requirements of real-time communication,
- exchanges finish in one-half to 1 roundtrip;

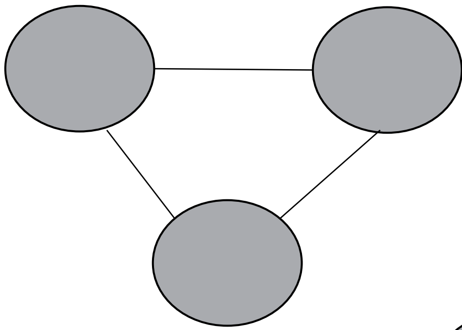
Group Key-Exchange: Mikey

MIKEY Scenarios (RFC3830)

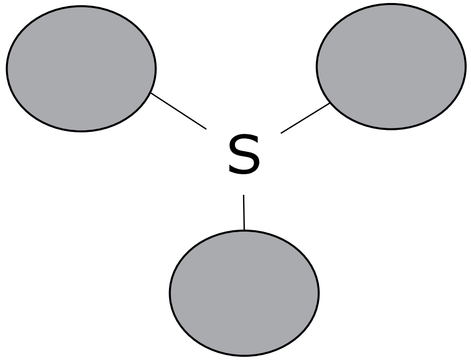
- Peer-to-Peer: simple one-to-many



- Many-to-Many (distributed)



- Many-to-Many (centralized)



Thank you

Questions?

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Further reading

http://datatracker.ietf.org/wg/msec/charter/