Service Architectures for 4G: The case of Multimedia Conferencing in Mobile Ad Hoc Networks

INSE 7110 – Winter 2007

Value Added Services Engineering in Next Generation Networks

Week #12

On the battlefield ...

▪

On the Battlefield …

Coordination and mission effectiveness of moving troops

- Commanders
- Soldiers (I.e. ranks)
  - Flow of orders from commanders to soldiers
  - Push-to-talk allowing soldiers to interrupt commanders in case of mergencies
  - Conferencing between commanders for coordination purpose
  - Whispers (I.e. private room, sub-conference) between sub-set of commanders for covert operations

Rescuing in natural disasters …

Rescuing in natural disasters ...

Rescuing in natural disasters …

Several parties are involved

- Medical group
- Police
- Fire brigade
- Rescue groups
  - Intra-group conferences
  - Inter-group conferences
  - May be as sophisticated in the battlefield scenario
    - Sub-conferences (I.e. private rooms, whispers)
    - Push-to-talk
    - orders

Pre-requisite I: Multimedia Conferencing …

Conversational exchange of voice or multimedia content between several parties

- Some examples:
  - Tele/video conference
  - Multiparty games
  - Distance learning

Pre-requisite I: Multimedia Conferencing …

The two main components

- Signaling
  - Establishment / modification / tearing down of the sessions
  - Logical links
  - Examples
    - Signaling system No7 (SS7)
    - Session Initiation Protocol (SIP), H 323, Megaco
- Media handling
  - Mixing
  - Content adaptation
  - Others

Pre-requisite II: (Mobile) ad hoc networks …

Networks that can be deployed, anywhere, any time

Some of the characteristics:

- Infrastructure-less
- Dynamically changing network topologies
- Physical layer limitations
- Variation in link and node capabilities
- Energy constraints

Pre-requisite II: (Mobile) ad hoc networks …

Categorization

- Multihop routing
  - Stand alone

  or

  - Connected to a fixed infrastructure
    - Can aid in extending 3G network coverage (i.e multihop cellular networks)

Mobile ad hoc networks and 4G …

4G

- Co-existence and cooperation between legacy networks and new networks
  - Typical legacy networks: 3G
  - Examples of new networks
    - Mobile ad hoc networks
    - Wireless sensor networks
- An example of cooperation
  - Network composition

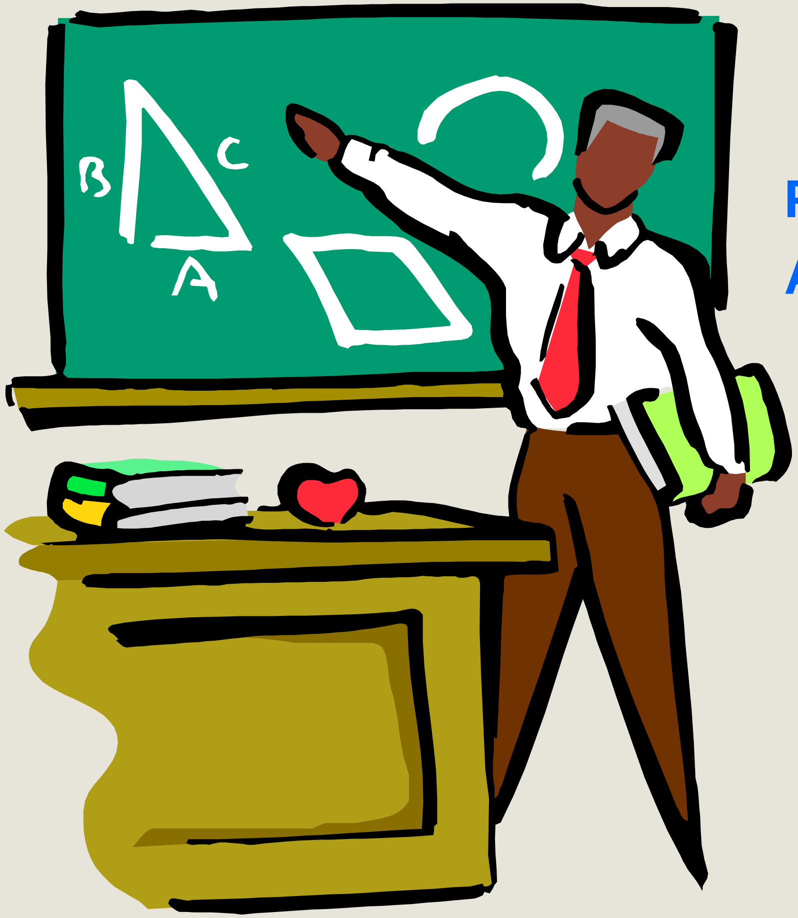
Multimedia Conferencing in Mobile Ad Hoc Networks

- Background
- Challenges and limitations of conventional approaches
- Emerging Approaches

Background ….

- Conferencing
- Mobile ad hoc networks

Conferencing ….



Functional classification schemes

Architectural classification schemes

Functional classification schemes

With / without floor control -

- Floor control
  - Coordination of the concurrent usage of shared resources and data
    - Who can be seen / heard
    - Who can speak

Ad hoc vs. pre-arranged

- Ad hoc: starts with 3 participants then grows / shrinks with time
  - Quite suitable for MANETs
- Pre-arranged
  - Starts at a pre-determined time and may also end at a pre-determined time
  - Sponsored by specific parties

Functional classification schemes

Private (closed) vs. public (open)

- Closed
  Only invited persons can join
- Open
  - Any party can join if it wishes to

With / without sub-conferences

- Sub-conferences
  - Simulates private rooms / whispers
    Participants in a same private room can hear/see each other (but cannot be heard / seen by other participants)

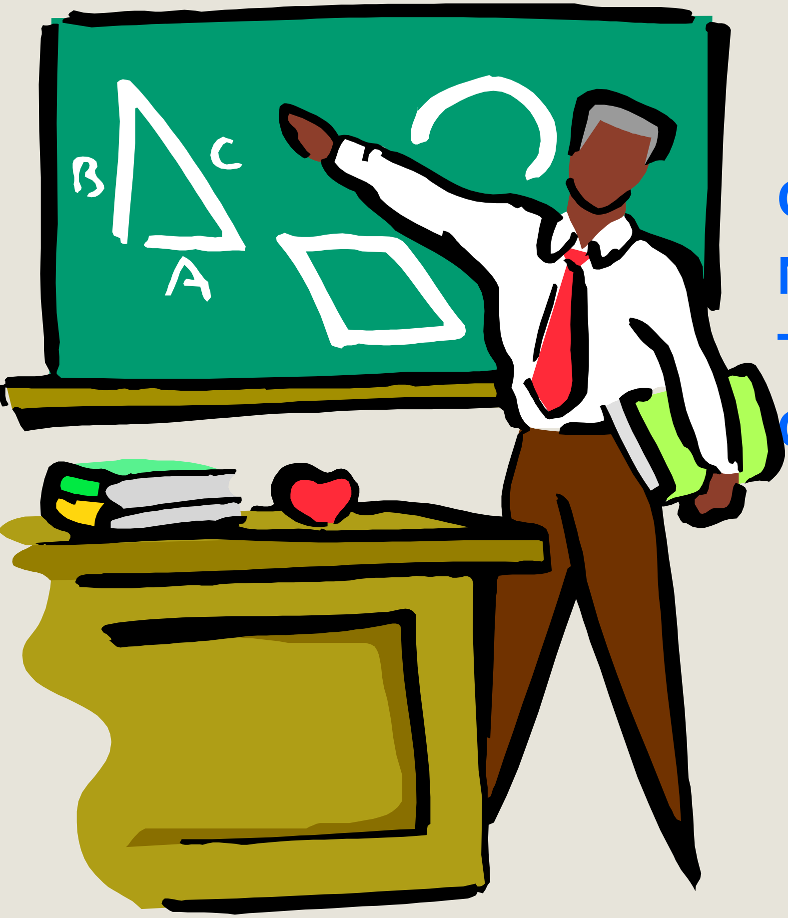
Architectural classification schemes

Based on topology of signaling and mixing -

- First extreme
  - Centralized signaling
  - Centralized mixing
    - Today's classical case: each participating node is connected to a centralized bridge
    - Signaling component and media component may be in separate boxes
      Example of standard interfaces
      Megaco / H.248

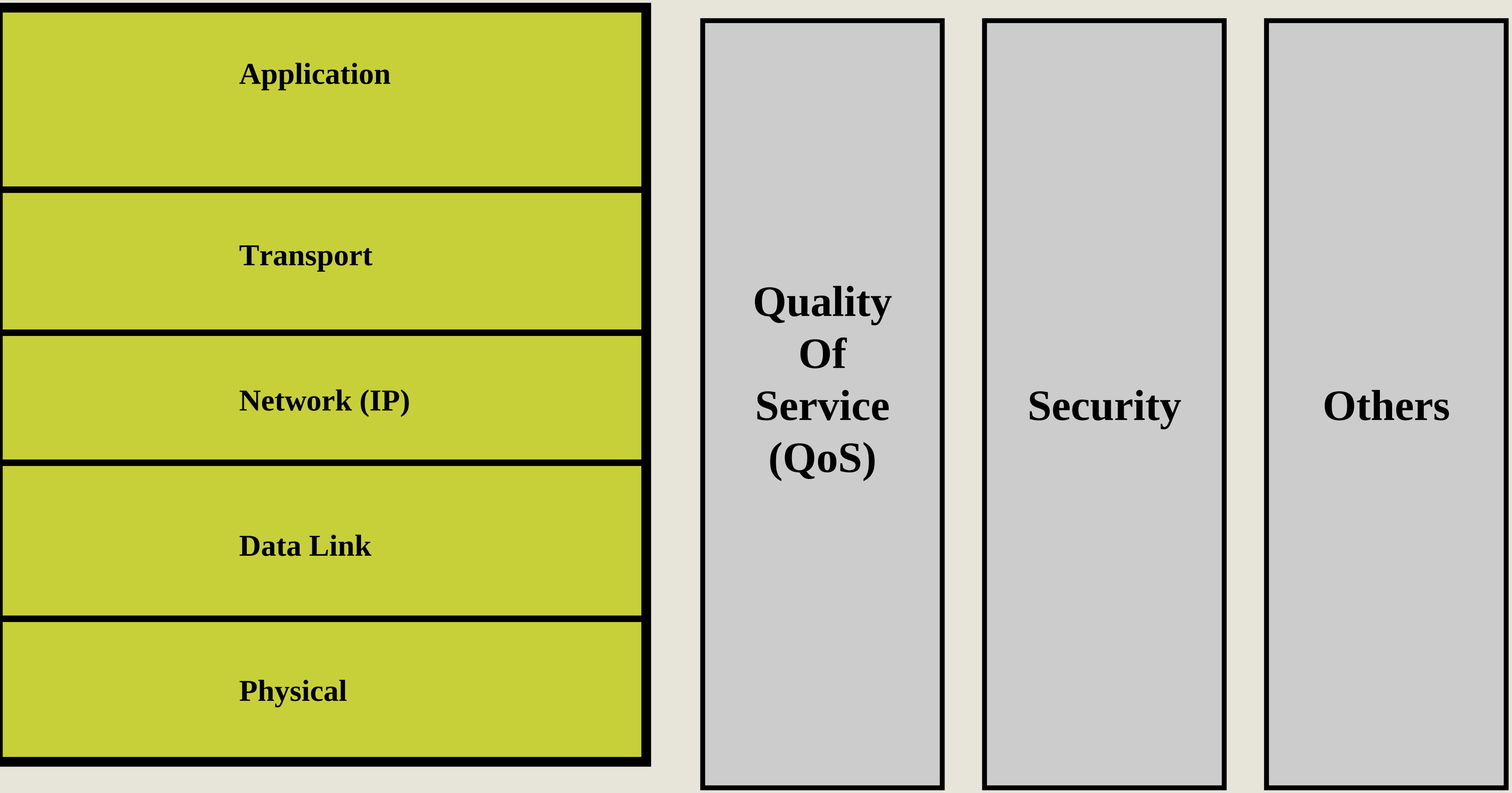
- Second extreme
  - Full mesh
    - Each participating node handles its own signaling
    - The same for mixing

Mobile ad hoc networks ....



Off the shelf building blocks (below IP)
Network layer (Routing)
Transport layer
Quality of service and security

Reference model ...



Below IP: The Off-the-shelf building blocks

From Wireless Personal Area Networks (WPANs) to Wireless Area Metropolitan Area Networks (WMANs)

Below IP: The Off-the-shelf building blocks

Wireless PANs -
BlueTooth (The most popular)
1 Mbps

- PHY (RF Layer)
  - Fast frequency hopping
- MAC (Baseband Layer)
  - Basic structure:
    - point to point
    - Master / slave
  - Piconet
    - Point to multipoint
    - 1 master controlling several slaves
  - Scatternets
    - 2 or more overlapping Piconets
    - Nodes which are part of more than one Piconet act as bridges

Below IP: The Off-the-shelf building blocks

Wireless PANs -

BlueTooth (The most popular)

Scatternets can be used as basis for multihop ad hoc networks

However:

- Few implementations of BlueTooth support scatternets
- Many open research issues
  - Efficient inquiry
  - Scatternet / piconet scheduling
- No working BlueTooth multihop ad hoc network test bed
- But simulators

Below IP: The Off-the-shelf building blocks

Wireless LANs -

1. IEEE 802.11 (a, b, c, d, e, f and g) – WiFi

- Most popular Off-the-Shelf building block
- 1 – 54 Mbps
- Two modes:
  - Infrastructure Mode Basic Service Set (IM-BSS)
    - Access points
    - Connections to a fixed network (e.g. 3G, Internet)
  - Independent Basic Service Set (IBSS)
    - No access point
    - Stand alone mode

Below IP: The Off-the-shelf building blocks

Wireless LANs –

IEEE 802.11 (a, b, c, d, e, f and g) - WiFi

- PHY
  - Most popular
    - Direct Sequence Spread Spectrum (DSS)
    - Orthogonal Frequency Division Multiplexing (OFDM)
      - More recent
      - Enable high rates
  - Have lost momentum
    - Infrared
    - frequency hopping spread spectrum (FHSS)

Below IP: The Off-the-shelf building blocks

Wireless LANs -
IEEE 802.11 (a, b, c, d, e, f and g) - WiFi

- MAC
  - Distributed Coordination Function (DCF)
    - Work in both IM-BSS and IBSS mode
    - Carrier Sense Multiple Access – Collision Avoidance (CSMA/CA)
    - Most popular
  - Point Coordination Function (PCF)
    - Polling scheme
    - Work only in the IM-BSS mode
    - Has lost momentum

Below IP: The Off-the-shelf building blocks

Wireless LANs -

1. Others (Much less popular)

- Infrared WLANs
  - Many disadvantages
    - Receiver and transmitter need to be visible to each other
    - Absorption by conventional obstacles
  - Still being used / researched due to the low cost
- Ultra Wide Band
  - Novel spread spectrum technology
  - No significant interference issue
  - First commercial chip set available
  - Military usage so far and strong restriction on commercial usage

Below IP: The Off-the-shelf building blocks

Wireless MANs -
IEEE 802.16 (WiMax)

- Emerging
- More than 200 Mbps
- Much wider coverage
- PHY
  - OFDM
- MAC
  - Designed to meet QoS requirements of a wide range of applications
  - Two sub-layers
    - Convergence specific
    - Common part

IP Layer: Routing

Pro-active approaches -

- Each node maintains the route to every other node
- Periodic updates
- Derived from wireline traditional routing approaches
- Examples
  - Distance sequenced distance vector (DSV)
  - Optimized link state routing (OLSR)

IP Layer: Routing

Reactive approaches -

- On-demand (built when needed)
- Some examples
  - Ad hoc On Demand Vector Routing (AODV)
  - Dynamic Source Routing (DSR)

IP Layer: Routing

Hybrid approaches -

- Integration of proactive and reactive approaches
  - Zone routing protocol

IP Layer: Routing

Geographical approaches -

- Built on the pro-active and re-active approaches
- Use in addition geographical information
  - GPS or other means
- Some examples
  - Location aided routing

Transport Layer

Examples of reasons for which TCP does not perform well in MANETs

Misinterpretations

- Interpret “wrongly” as congestion:
  - Packet loss
  - frequent path breaks

Network partitioning and re-merging

- Due to randomly moving nodes

Transport Layer

Two possible alternatives

1. Enhanced versions of TCP
   - Not really new as research area
   - Several proposals exist for wireless
2. Brand new transport protocols
   - Issue: Inter-working

   May not be critical in specific environements (e.g. military applications)

   Examples

   - Application control transport protocol

     More like UDP but

     maintain state

     Give feedback about delivery

Quality of service

QOS:

Performance level of a service offered to an user

Case of MANETs – Strong dependance on:

- Battery charge
- Processing power
- Buffer space

QoS in MANETs

Classification of solutions:

- MAC layer (e.g. IEEE 802.11: enhanced distributed coordination function – DCF)
  - Enhance CSMA-CA by providing differentiated access to the medium
- Network layer (e.g. QoS routing protocols –
  - Search for routes with sufffficient ressources to meet the QoS requirements of a flow

Security in MANETs

Same issues but much more critical at some layers such as routing since all nodes are involved:

- Examples
  - Confidentiality
  - Integrity
  - Non repudiation

Security in MANETs

Examples of requirements of a secure routing protocol:

Detection of malicious nodes
Guarantee of correct route discovery
Confidentiality of network topology
Stability against attacks

Examples of secure routing protocols

- Security aware routing protocol
- Secure efficient ad hoc distance vector routing protocol

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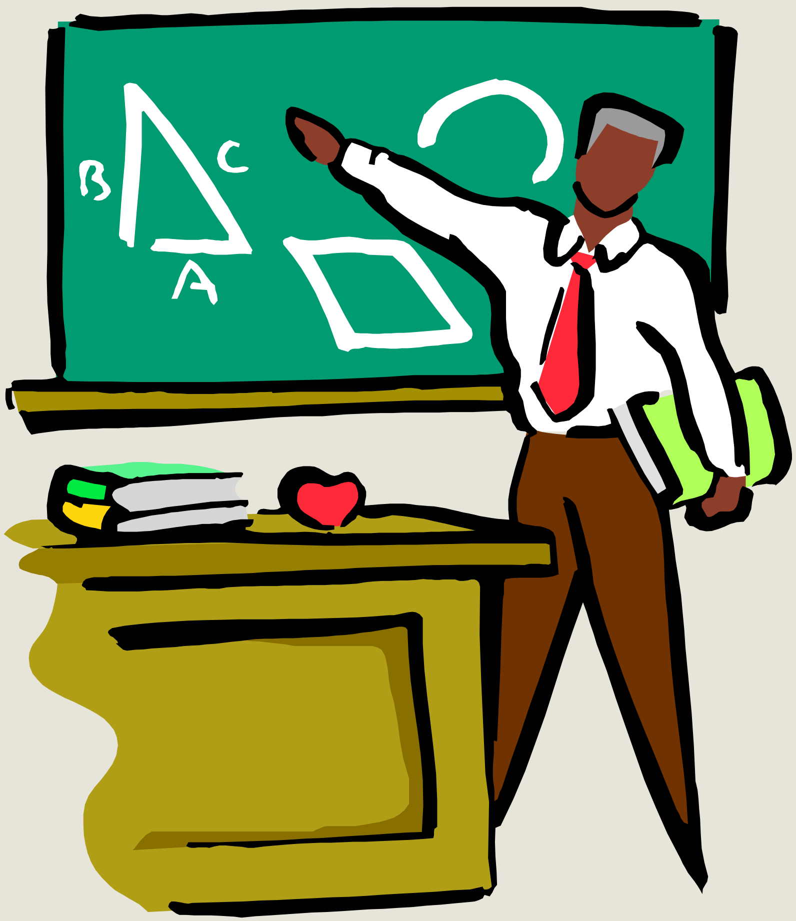
To probe further …

1. S. Basagni et al., editors, Mobile ad hoc networking, IEEE / Wiley Press, 2004
2. C. Siva Ram Murthy and B.S Manoj, Ad Hoc Wireless Networks: Architectures et Protocol, Prentice Hall 2005
3. A. Al Hanbali and al, A Survey of TCP over Ad Hoc Networks, IEEE Communications Surveys & Tutorials, Third Quarter 2005, Vol.7, N.3
4. A. Gosh et al., Broadband Wireless Access with Wimax 802.16: Current Performance, Benchmarks and Future Potential, IEEE Network Magazine, February 2005

Conferencing Challenges and Traditional apporaches ….

- Challenges
- Traditional standard approaches
- Traditional non standard approaches

Challenges ….



- General challenges
- Signaling specific challenges

General challenges …

1. No centralized entity
2. Optimal usage of resources
3. Lightweigth
4. Independence of lower layer protocols (e.g. Routing)
5. Scalability

Examples of signaling specific challenges …

Signaling specific

- Dynamic propagation of conferencing information (e.g. who has joined, who has left)
  - Very challenging in MANETs due to the frequent changes in topology
    - Voluntary departure (easy to handle)
    - Forced departure (trickier)

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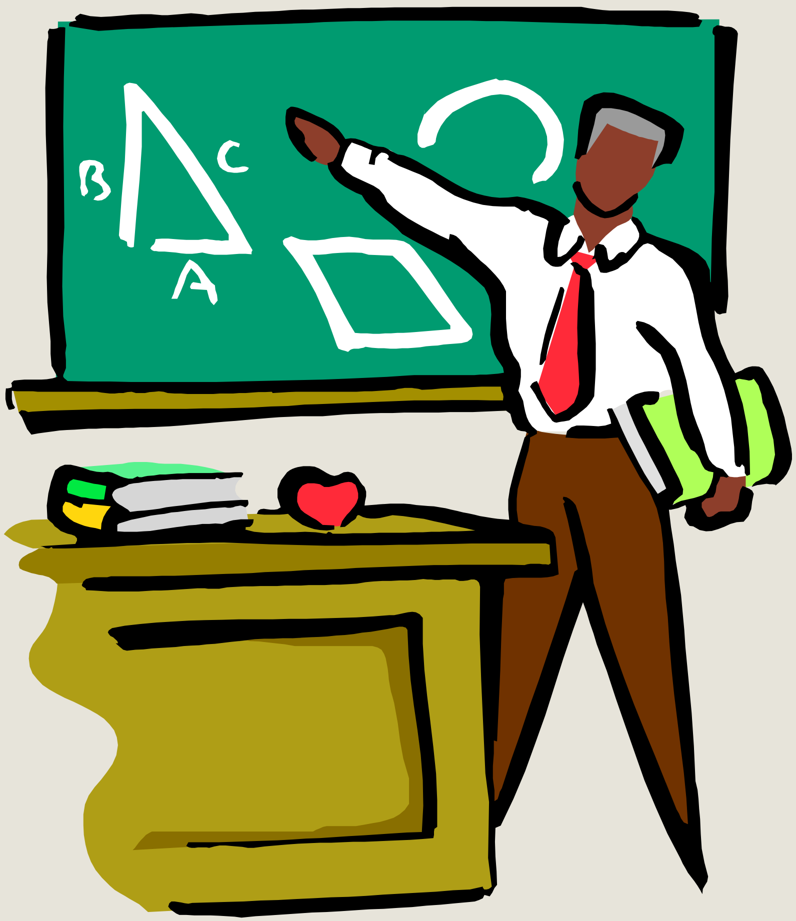
Standard Approaches to Conferencing ….

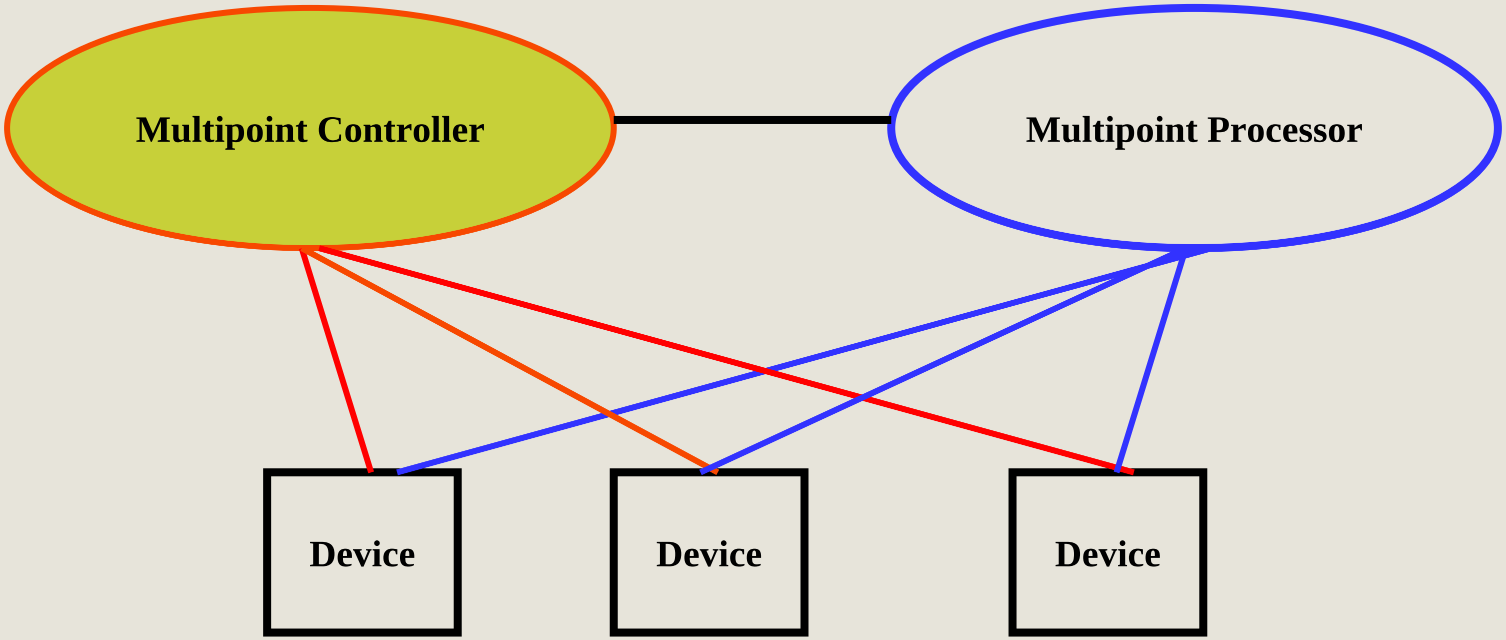


- H.323
- SIP

H.323 – Conferencing

Multipoint control unit (MCU)
- Provides conferencing functionality
  - Multipoint Controller
    - Signaling entity
    - Central control point
    - Mandatory
  - Multipoint Processor
    - Media handling entity
    - Optional (Not needed when media is distributed via mulicast)

H.323 – Conferencing



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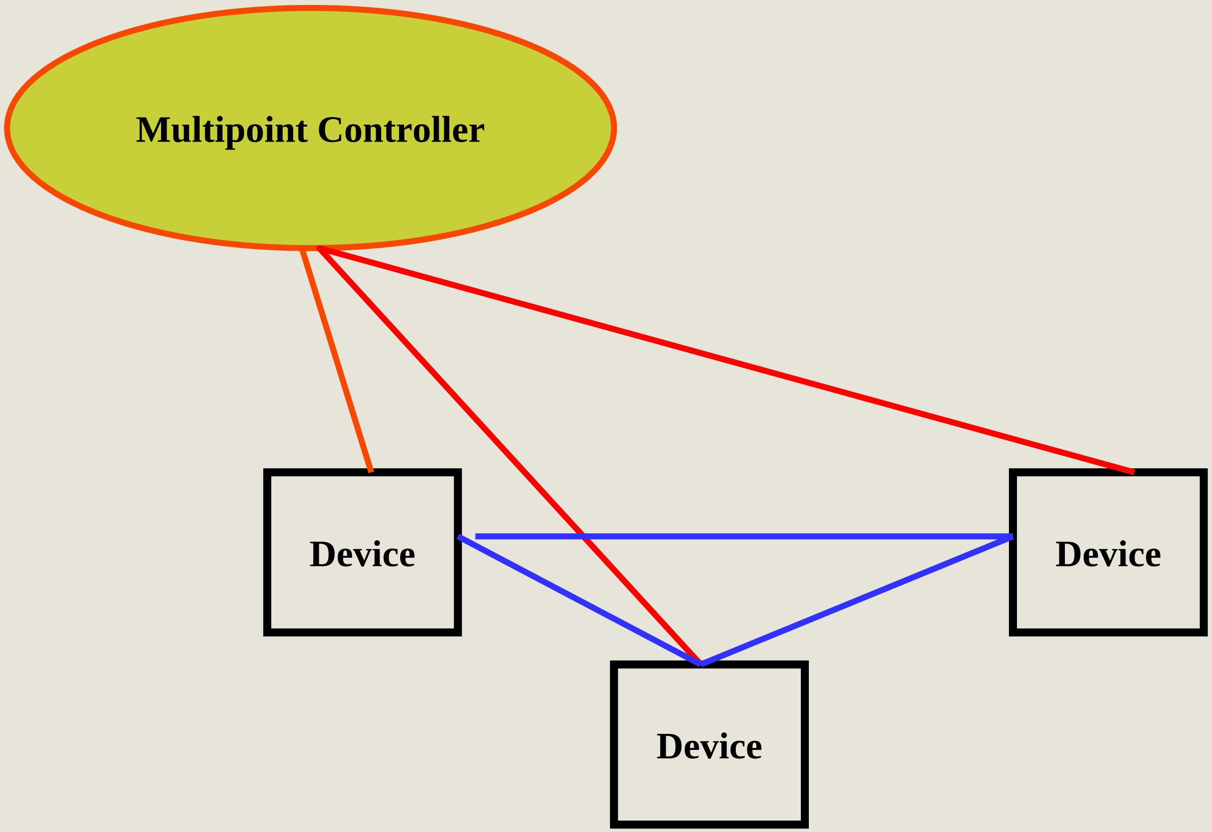
H.323 – Conferencing



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H.323 and the general challenges …

1. No centralized entity

   No (Multipoint controller is a centralized entity – Same applies to MP when it is there)

2. Optimal usage of resources

   No (Level of resource not taken into account)

3. Lightweigth

   No (Known as heavy)

4. Independence of lower layer protocols (e.g. Routing)

   Yes

5. Scalability

   No (MC can become a bottleneck)

H.323 and the signaling specific challenges …

Signaling specific

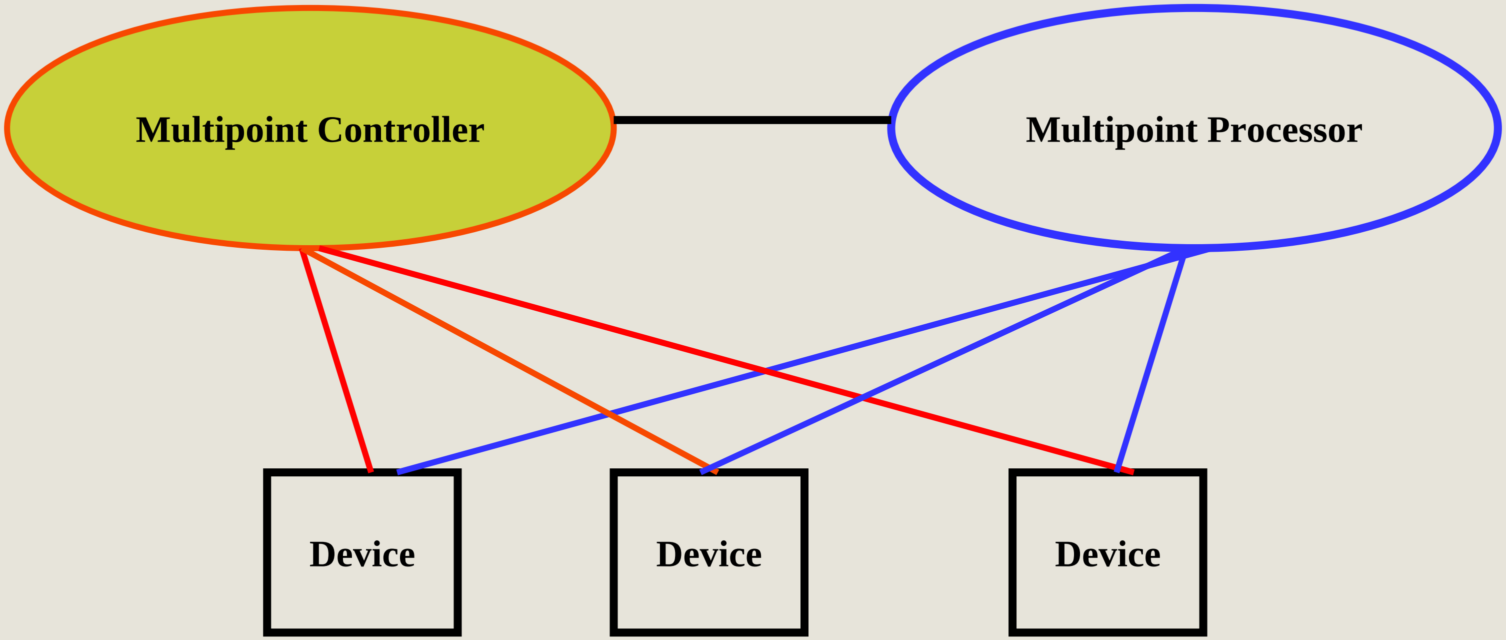
- Dynamic propagation of conferencing information (e.g. who has joined, who has left)
- Not applicable - (H 323 does not allow the conferencing model where participants cab join and leave as they wish)

SIP – Conferencing

Several models

- Centralized
- Full mesh
- End system mixing

SIP – Conferencing



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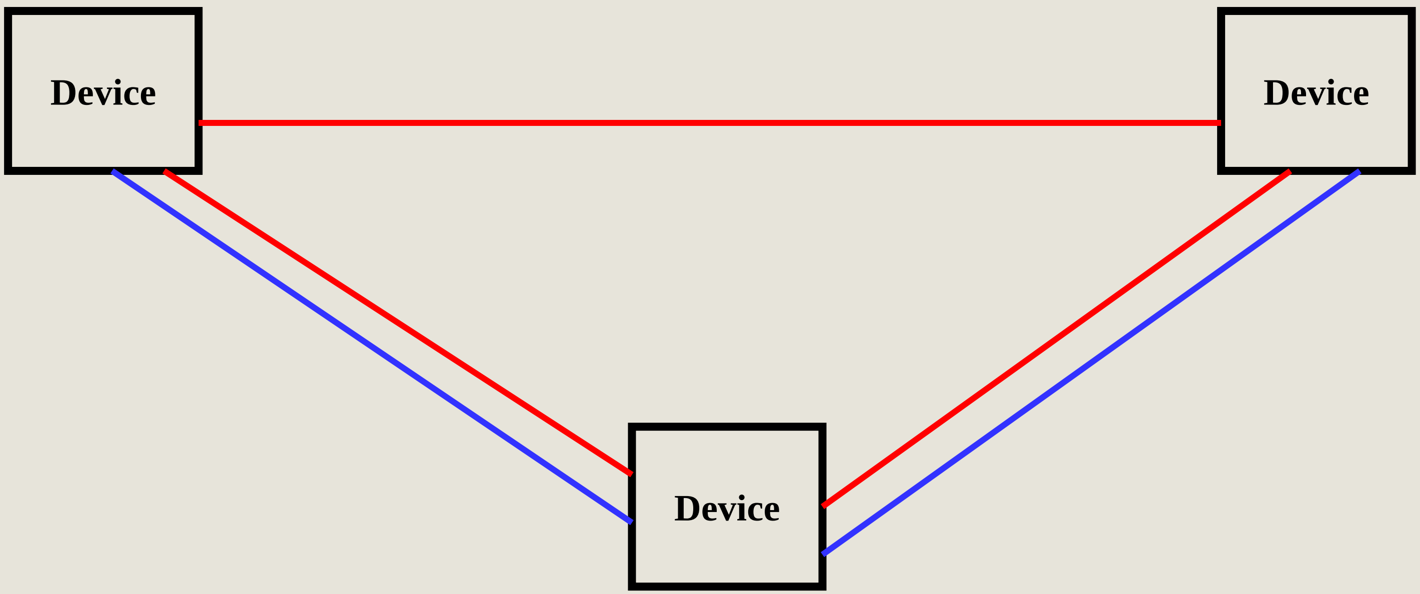
SIP – Conferencing



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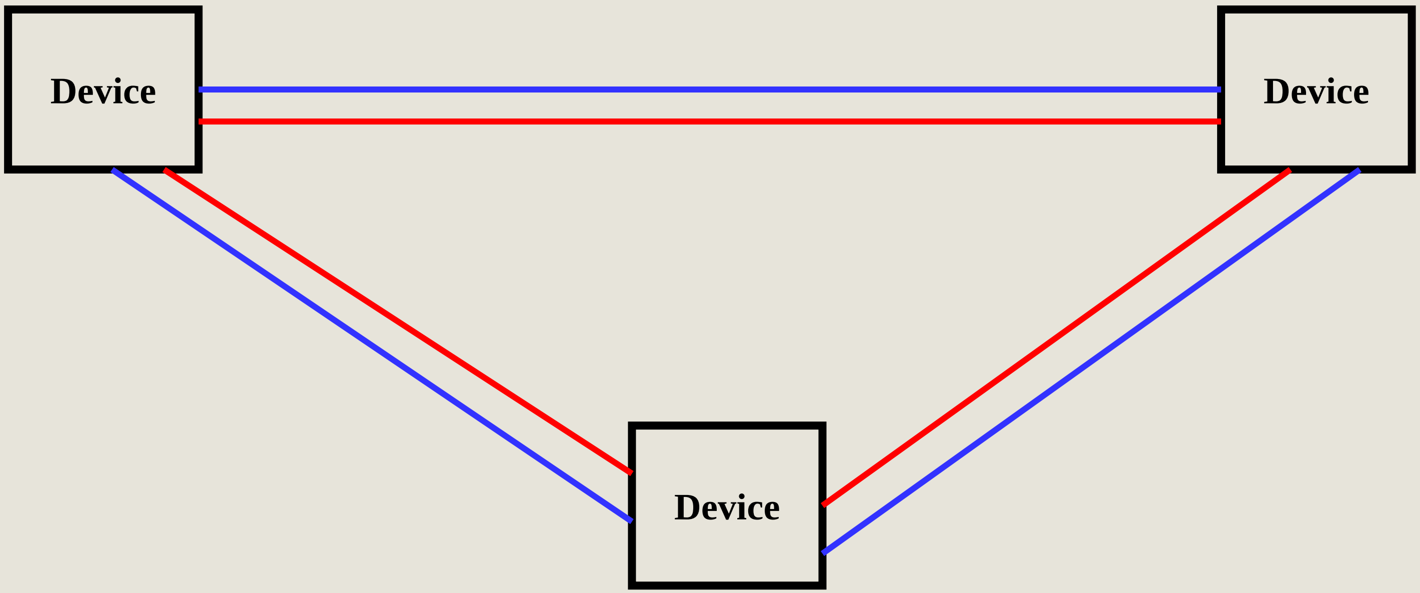
SIP – Conferencing (Most interesting case for MANETs)



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SIP (Full mesh) and the general challenges …

1. No centralized entity
   Yes
2. Optimal usage of resources
   No (Level of resource not taken into account)
3. Lightweigth
   Yes (Known as not heavy)
4. Independence of lower layer protocols (e.g. Routing)
   Yes
5. Scalability
   No (Exponential growth of number of signaling links)

SIP (Full mesh) and the signaling specific challenges …

Signaling specific

- Dynamic propagation of conferencing information (e.g. who has joined, who has left)
- No - (Problem when 2 or more participants join at the same time)

To probe further ...

- A. Moderassi and S. Mohan, Advanced Signaling and Control in Next Generation Networks, Special issue IEEE Communications Magazine, October 2000

- C, Fu, R. Glitho and R. Dssouli, A Novel Signaling Systems for Multiparty Sessions in Peer to Peer Ad Hoc Networks, IEEE Wireless Communications and Networks Conference, March 2005, New Orleans (WCNC 05)

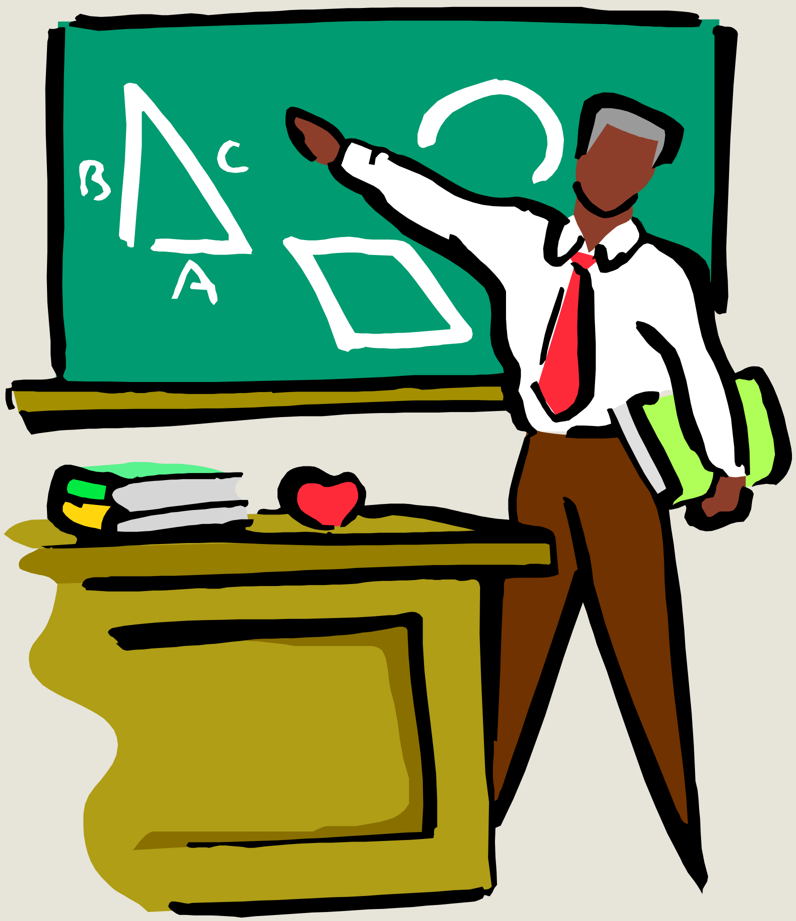
- D. Ben-Kheder, R. Glitho and R. Dssouli, Media Handling for Multiparty Sessions in Ad-hoc Peer-to-Peer Networks: A Novel Distributed Approach, IEEE International Symposium on Computer Communications, Cartagena, Spain, June 2005 (ISSC05)

- D. Ben-Kheder, R. Glitho and R. Dssouli, Media Handling Aspects of Multimedia Conferencing in Broadband Wireless Ad Hoc Networks, IEEE Network Magazine, March/April 2006

Emerging Approaches ….

- Signaling

Signaling ….



- **Clusters based signaling**

Towards Cluster Based Signaling for MANETs ….

- Potential of application level clusters
- An example of a cluster based signaling architecture for MANETs
  - Functional entities
  - Clusters life cycle
  - Implementation
  - Potential performance bottlenecks
  - Cross layer optimization

Potential of application level clusters …

1. No centralized entity

   Yes - clusters heads can act on transient basis (i.e. there will no permanently centralized entites)
2. Optimal usage of resources

   Yes - If the level of resource is taken into account when cluster heads are elected
3. Lightweigth

   Yes – If appropriate implementation technologies are selected
4. Independence of lower layer protocols (e.g. Routing)

   Yes - If clusters are built at application level independently of the clusters which may (or may not) exist at lower layers such as routing
5. Scalability

   Yes - clusters can split (and eventually merge)

Potential of application level clusters …

Dynamic propagation of conferencing information (e.g. who has joined, who has left)

Yes - If an appropriate mechanism is implemented

Potential of application level clusters …

Examples of issues:

- Sub-optimal routing at network layer
  - Clusters members may be too far from cluster-head
- Re-discovering node capabilities / resource level (when electing cluster-head) at application level
  - Information may exist at lower layers

Example of solutions:

- Cross layer design (i.e. violates the independence between layers – allow for instance the applicaton layer to get information from the network layer)

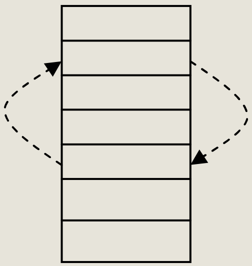
Digression on Cross-Layer Design

- Active exploitation of the dependence between protocol layers to obtain performance gains**.
- Motivations
  - Layered design works well in wired networks
  - Characteristics of wireless network are different
    - Physical layer may affect MAC and routing decision (e.g. transmission power/ rate)
    - TCP congestion may be caused by a link break

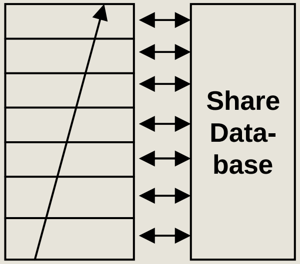
** *Vineet Srivastava and Mehul Motani, "Cross-Layer Design: A survey and the Road Ahead", IEEE communication Magazine, Dec 2005, Page 112- 119*

Digression on Cross-Layer Design

- Examples of approaches
  - Interface: upward, downward, back and forth
  - Merging adjacent layers
  - Shared database
  - New abstractions such as heaps



Interface: Back and force



Shared database across layers

Digression on Cross-Layer Design

- Some Pros and cons
  - Pros: performance gains
    - Improved performance :
      - each layer may perform optimally and all layers together may provide a better service
    - Reduction og overhead:
      - avoid data duplications
    - Extra services may be provided, (e.g. context aware services)
  - Cons:
    - Loops may occur
    - Hard to upgrade and add new functions

An Example of application cluster based architecture Signaling Entities (stand alone MANETs)

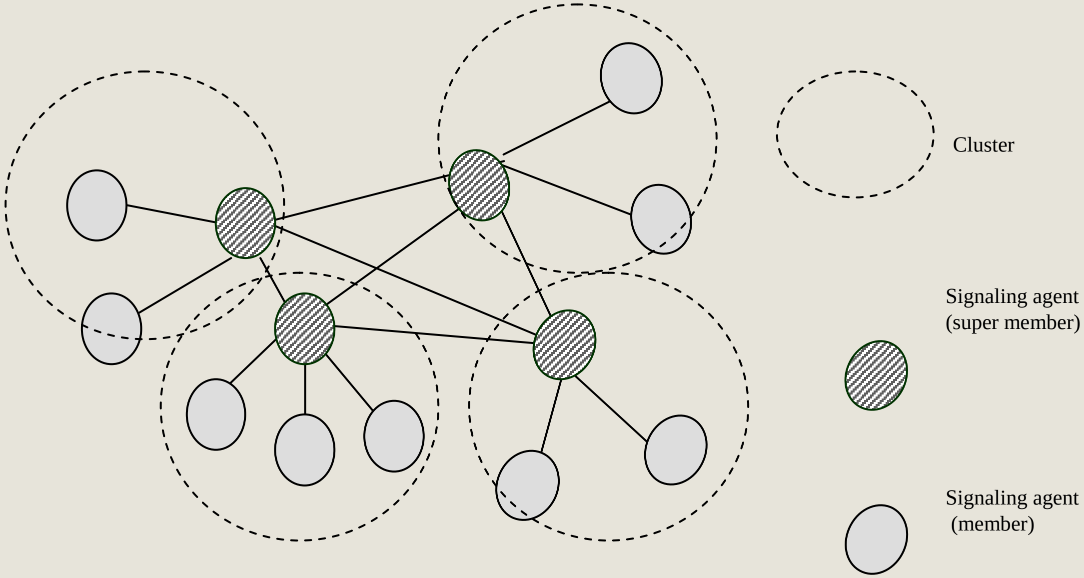
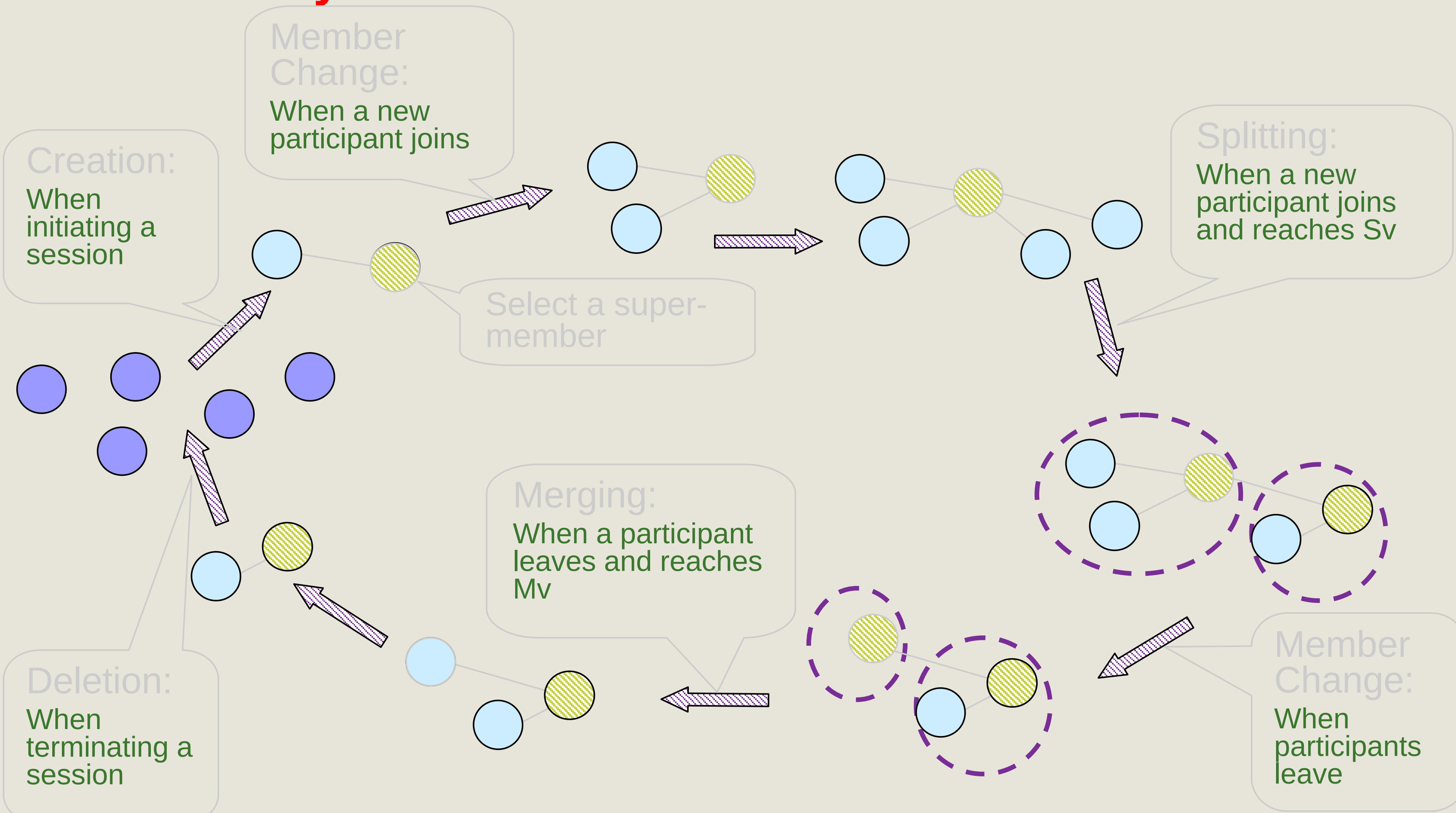
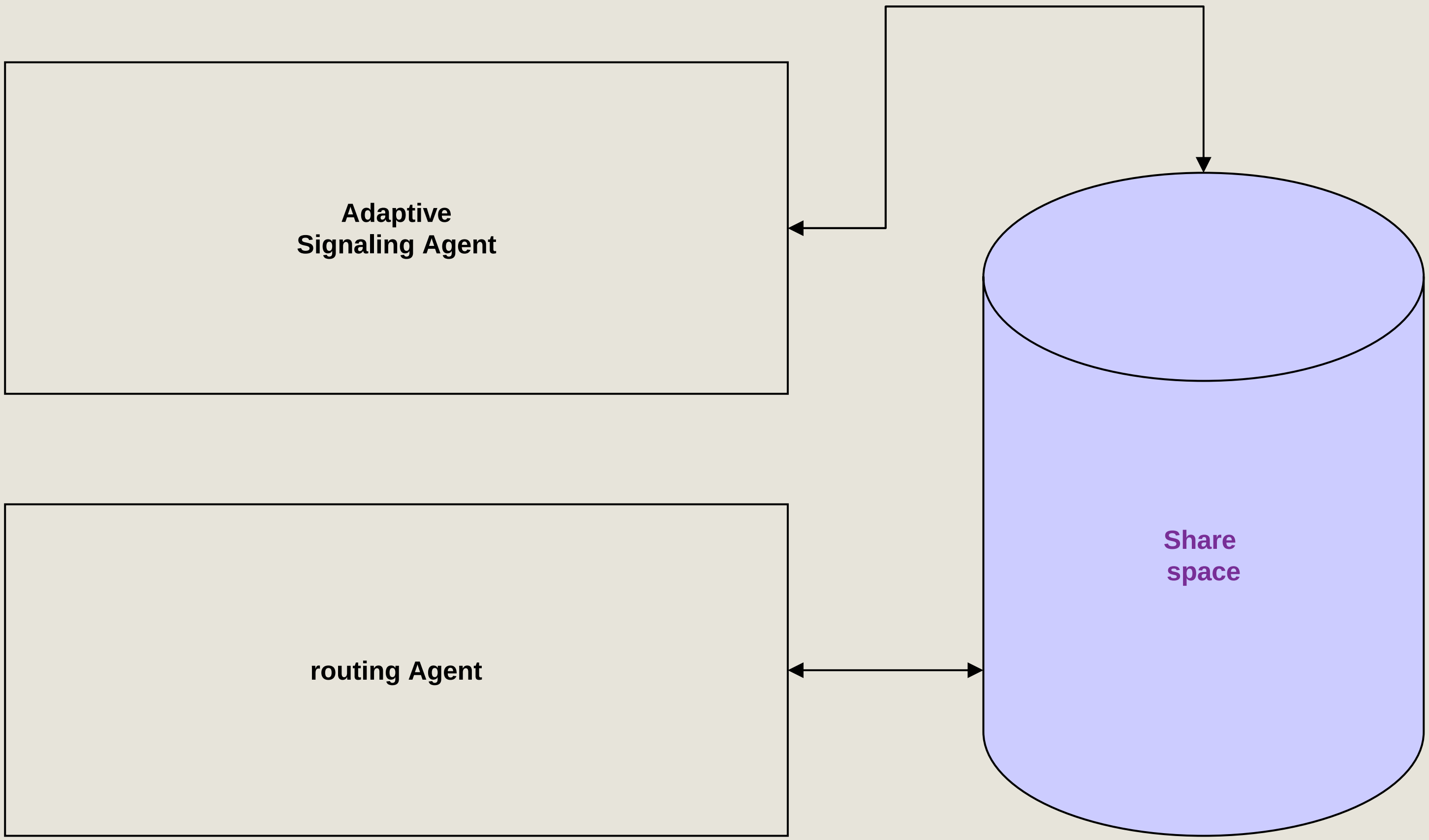


Fig. 1. An overall view of the architecture

An example of application level cluster based architecture - Clusters' Life Cycle



An example of optimization with cross layer design



The Case of Integrated 3G/MANET

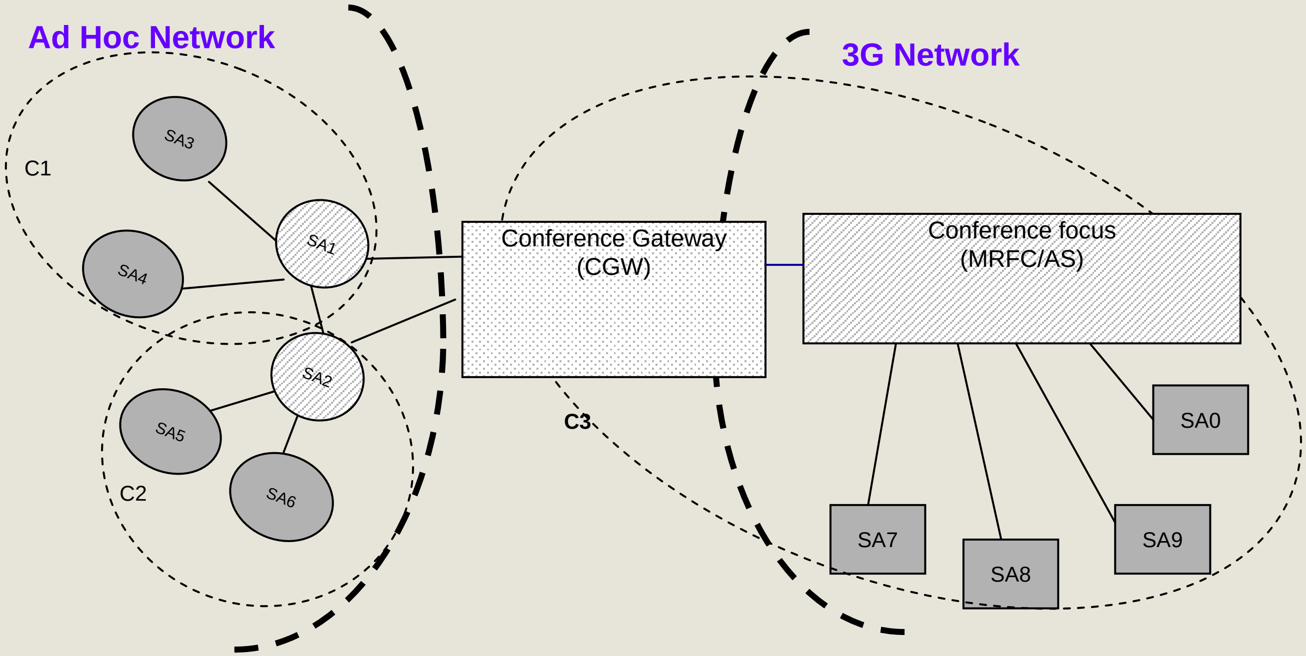


Figure 3. Integrated conferencing architecture

The Case of Integrated 3G / MANETs ...

Conference gateway

- Mediator between 3G and MANETs
  - Two signaling interfaces
    - Can establish sessions between participants in MANET and participant in a 3G
    - Can map signaling architectures and protocols
    - Collects and distribute membership information

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The Case of Integrated 3G / MANETs ...

Conference gateway

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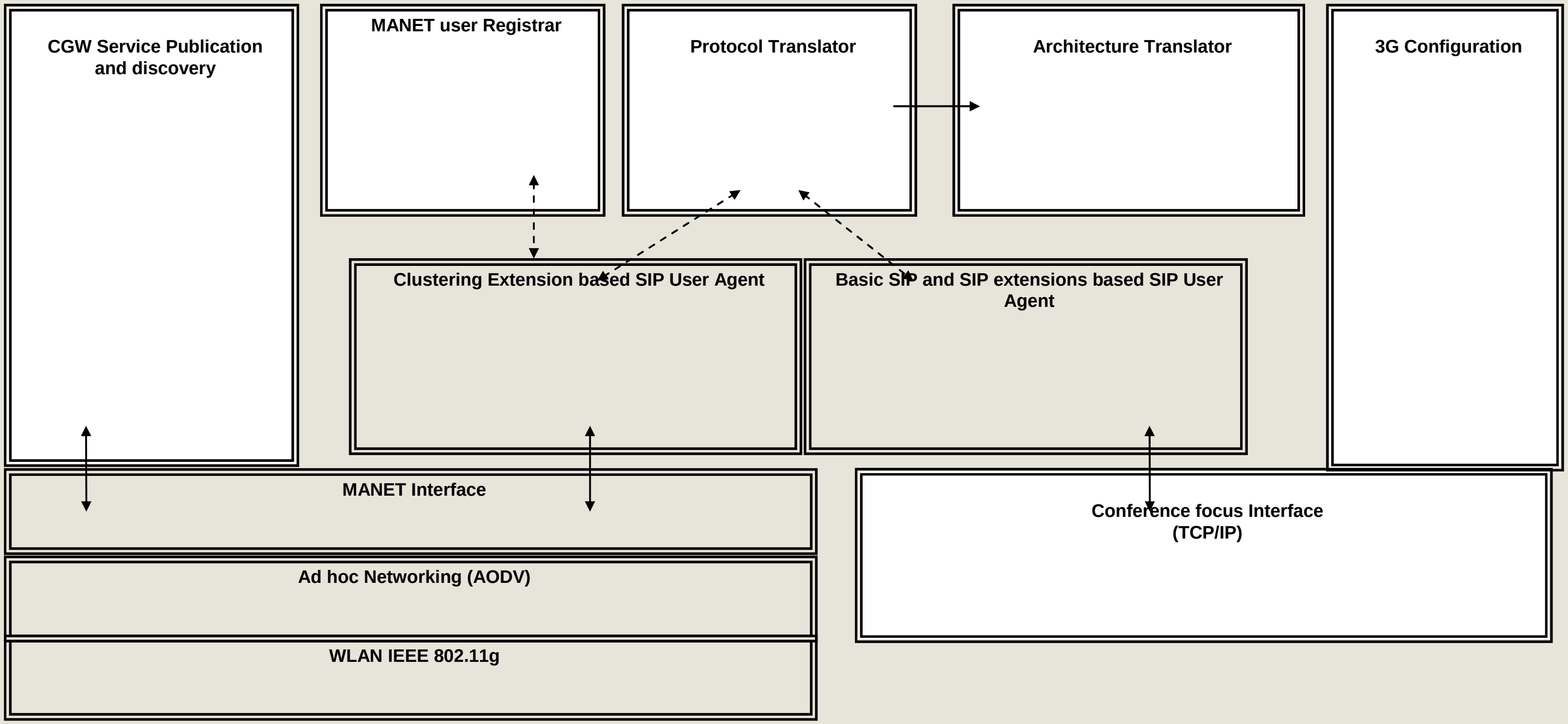

Figure 7. Conference Gateway Structure

To probe further ...

- C, Fu, R. Glitho and R. Dssouli, A Novel Signaling Systems for Multiparty Sessions in Peer to Peer Ad Hoc Networks, IEEE Wireless Communications and Networks Conference, March 2005, New Orleans (WCNC 05)
- C. Fu, R. Glitho and F. Khendek, Signalling for Conferencing in Integrated 3G / Mobile Ad Hoc Networks, *IEEE Internaltional Symposium on Computers and Communications (ISCC'06)*, June 26-29, Sardinia, Italy
- C. Fu, R. Glitho and F. Khendek, Signalling for Conferencing in 4G: The Case of Integrated 3G / Mobile Ad Hoc Networks, *IEEE Communications Magazine*, August 2006, pp. 90-99
- C. Fu, R. Glitho and F. Khendek, Cross-Layer Design for Optimizing the Performance of Clusters-Based Application Layer Schemes in Mobile Ad Hoc Networks, IEEE Consumer Communications & Networking Conference 2007 (IEEE CCNC 07), Las Vegas, January 11-13, 2007

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