Ad-hoc Wireless Networks for Video Distribution

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What problems are we addressing?

- Internet multimedia collides with wireless LAN
  - How to send video (TV, DVD, …) from A to
  - B, who may not be able to communicate with A
- Why?
  - It is interesting anyway to explore general situations where this could happen
  - And this has occurred to many other people over the last 20 years
  - And it seems now to be something that is needed, and is useful and usable, as well an exercise in theory (which is still quite a problem)
  - So, what new contribution can be made?

Some (technical) scenarios

- Video sources are:
  - Elastic
    - Streamed, using RTP plus UDP or TCP (with a bit of thought)
    - Buffering covers embarrassment
  - Inelastic
    - Conferencing
    - Real-time TV
- Quite a lot of experience with IP in fixed networks, even using multicast
- When does it get more interesting?

More on scenarios

- It gets more interesting when there are…
- Thousands of nodes nearby with wireless access
- Lots of sources of various specifications
  – Bit-rate, resolution, protocol
- There is no permanent network, or possibly several visible to some nodes
- Nodes are willing to forward packets to each other but they will run out of power if they do it too much
- Where does this happen?
  – Sporting events that move location irregularly
  – Unpredictable progress of the event

The answer is IP (of course) but…

- Or is it?
- IP is good at host to host (P2P, client/server)
- It is not good at diffusion
- Multicast is still problematic
- Performance is variable and QoS requirements can be compromised
- And this will only be worse in the scenario described
- But we will try anyway...

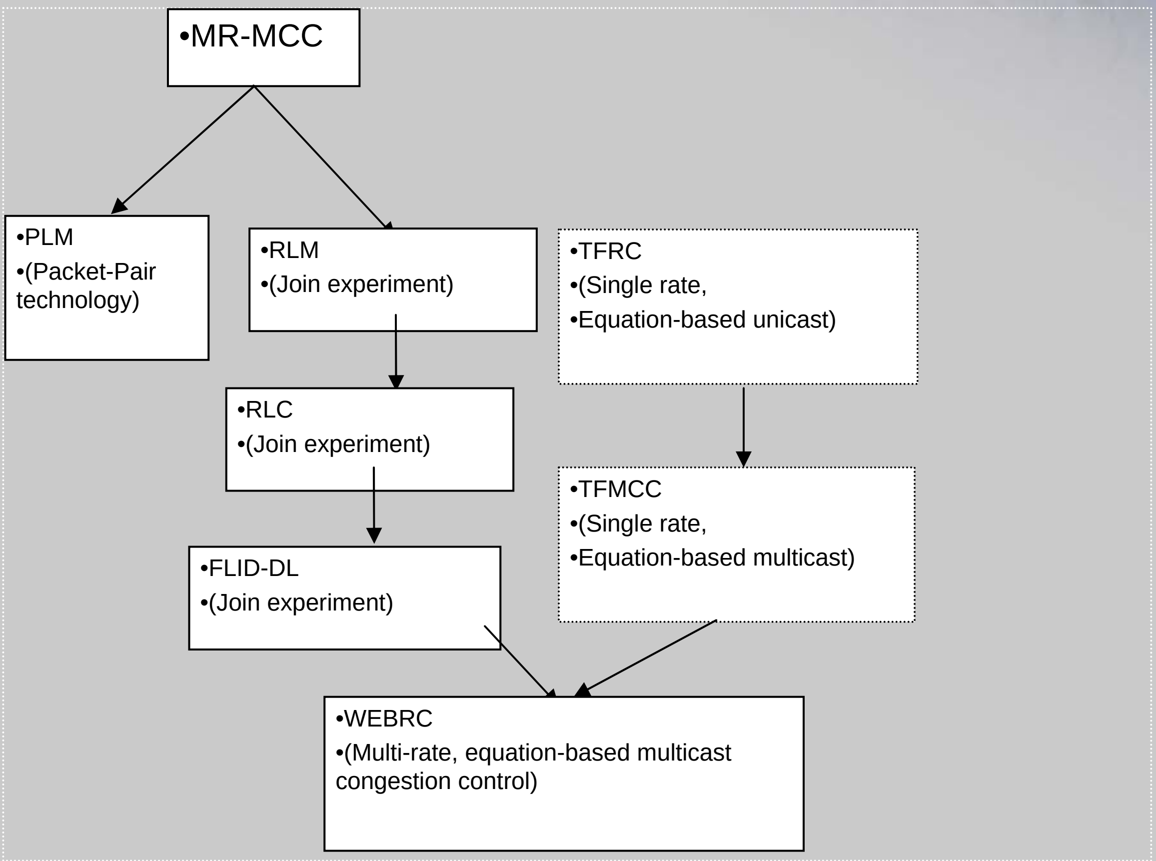
What will help us?

- Application: scalable video coding
  - Base layer transmitted separately from higher quality layers
- Network:
  - Multicast with rate control and congestion management
  - Must accommodate big variations in bandwidth delay product
  - Management of throughput, loss and delay (QoS)
- Link and PHY (device to device)
  - Quality starts (to be lost) here
    - Interference and noise
    - Contention
    - ARQ (delay)
    - Loss of energy

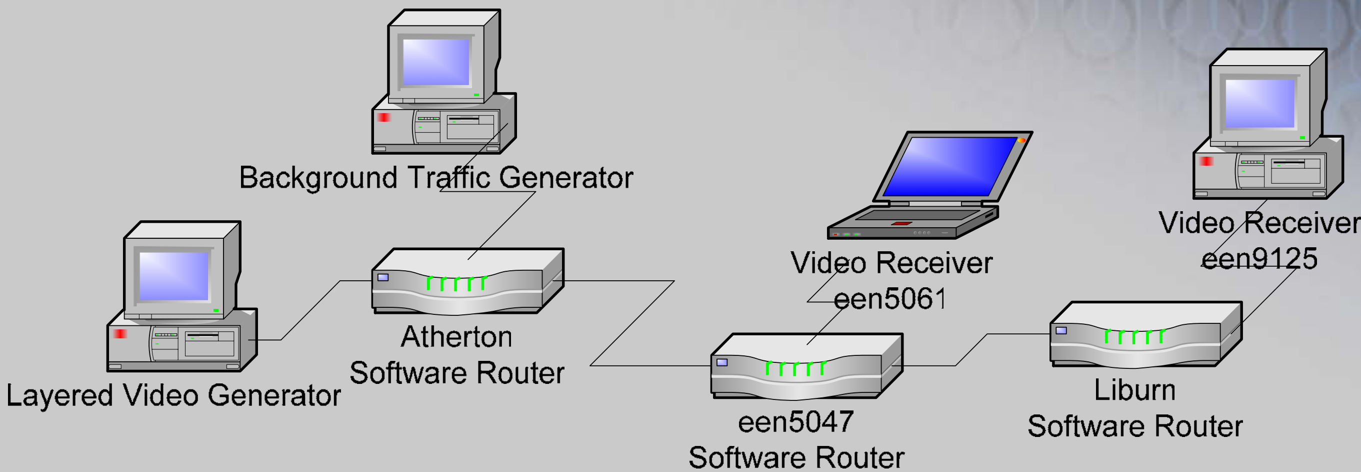
From the top…

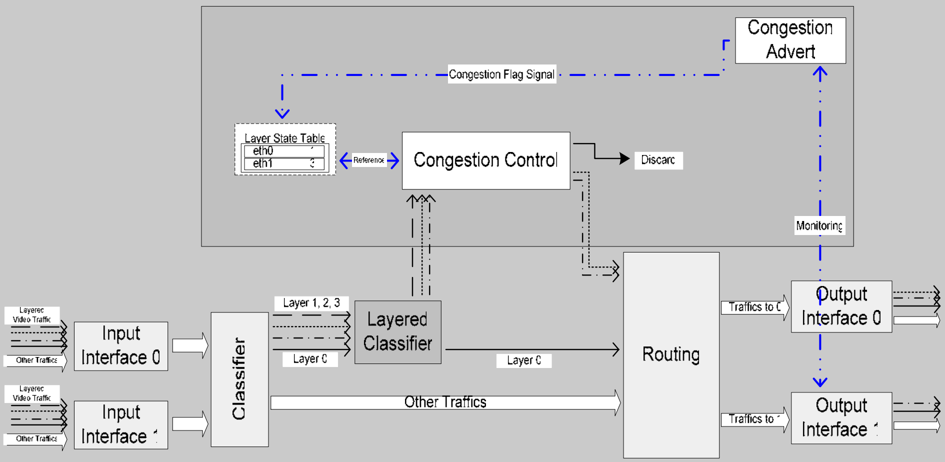
- Experiments with layered multicast and congestion control
- QoS for 802.11[abeghn]
- Mobility and routing
- Propagation

Multi-rate, congestion control and IP Multicast



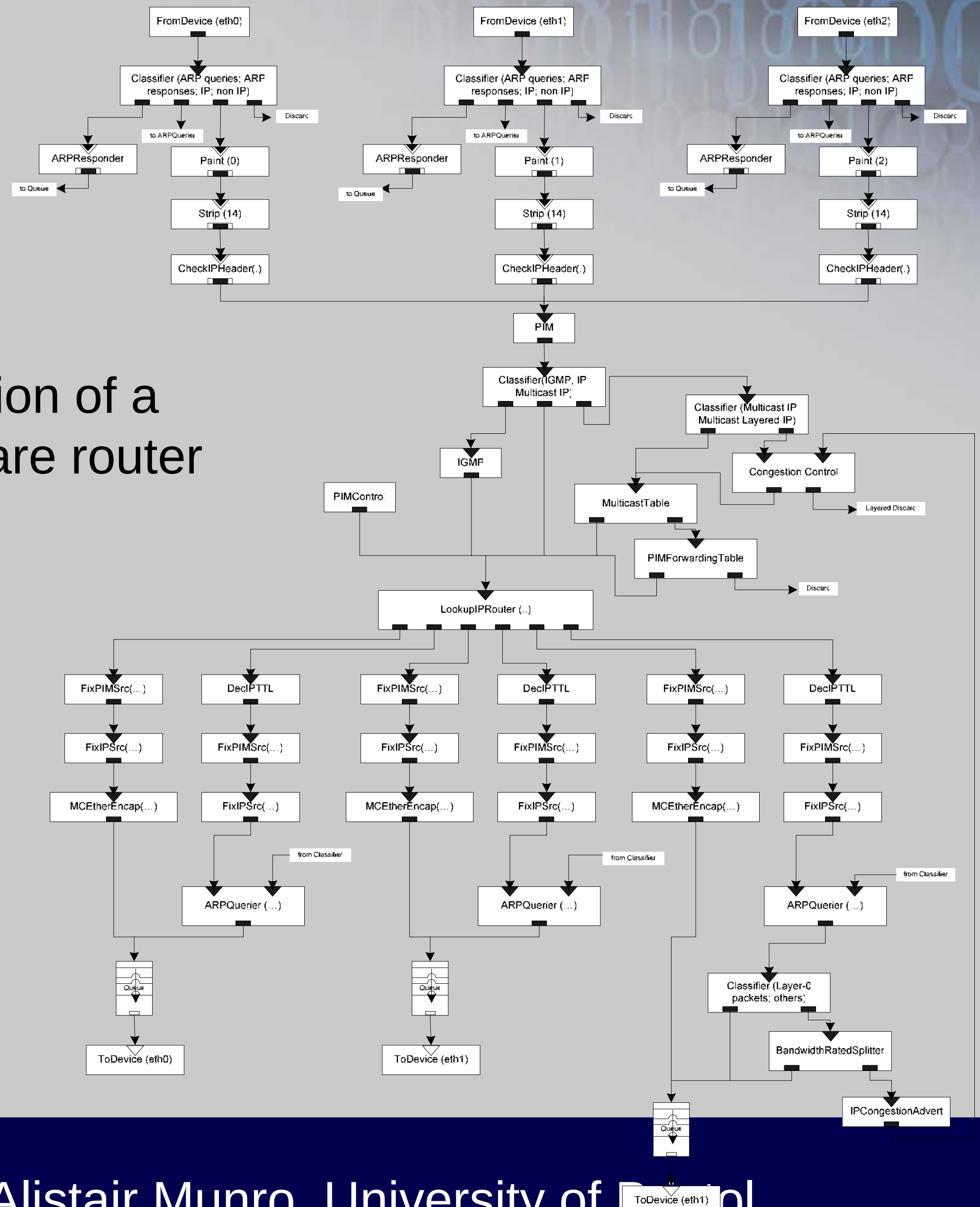
Layered Video Multicast Test-bed





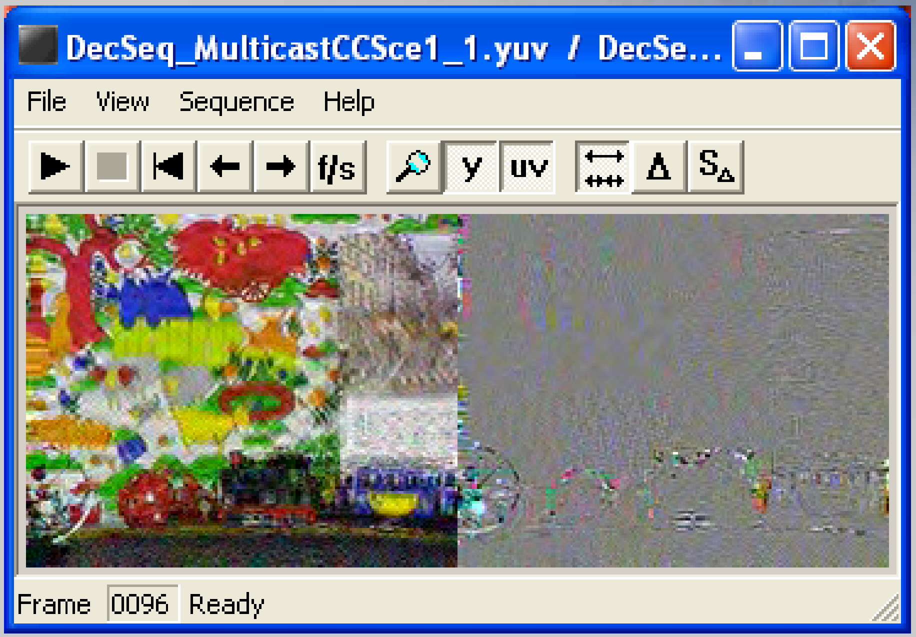
Layered Video Multicast Test-bed (2)

•Configuration of a Click software router



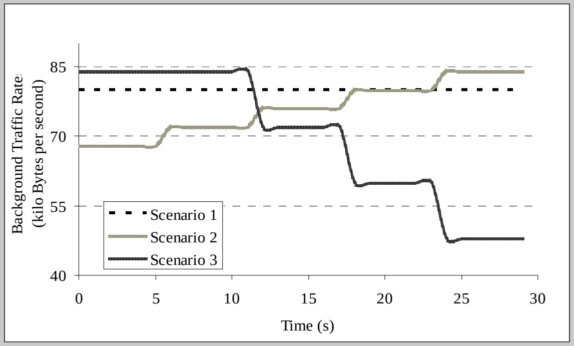
Performance Evaluation (1)

Original video vs. Video with congestion control

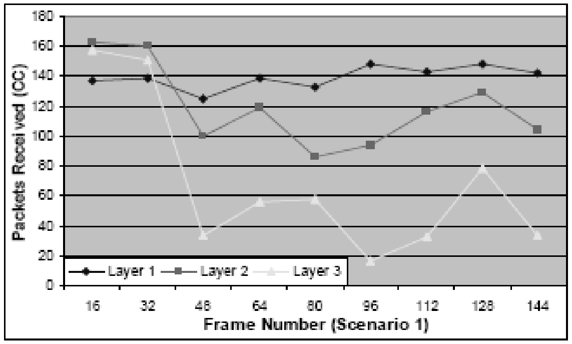


Video with congestion control vs. Video without congestion control

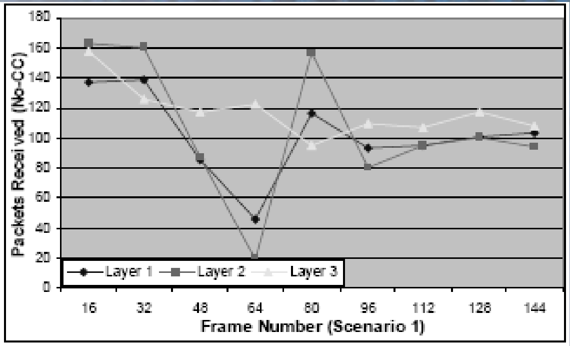
Performance Evaluation (2)



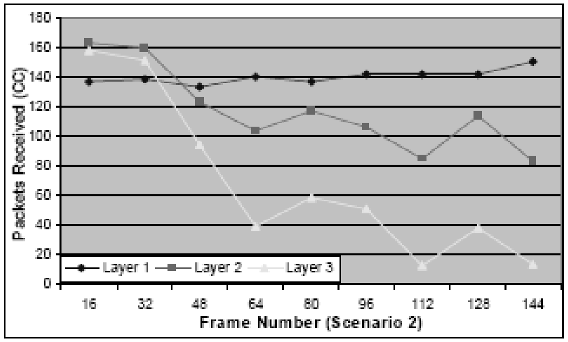
Background Traffic Transmission Rate for the Three Scenarios



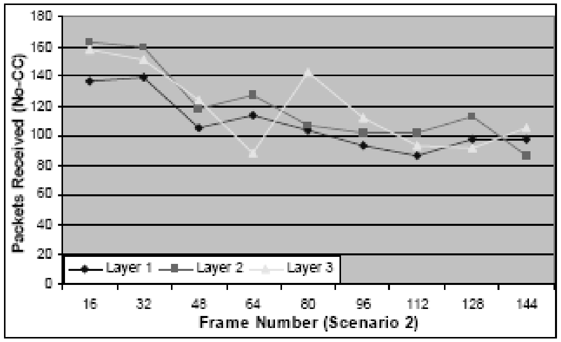
Graph1



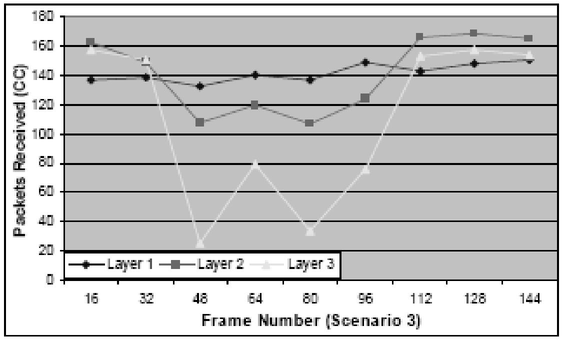
Graph2



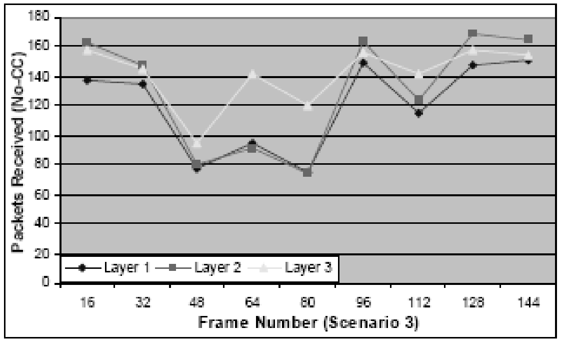
Graph3



Graph4

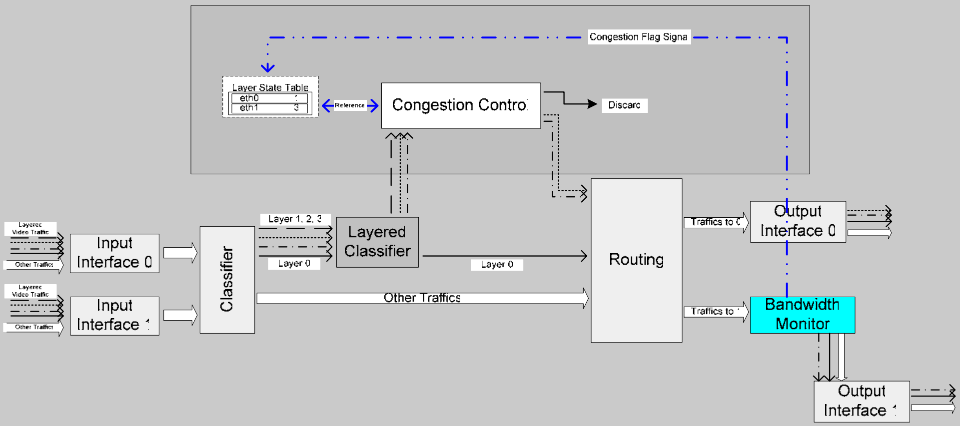


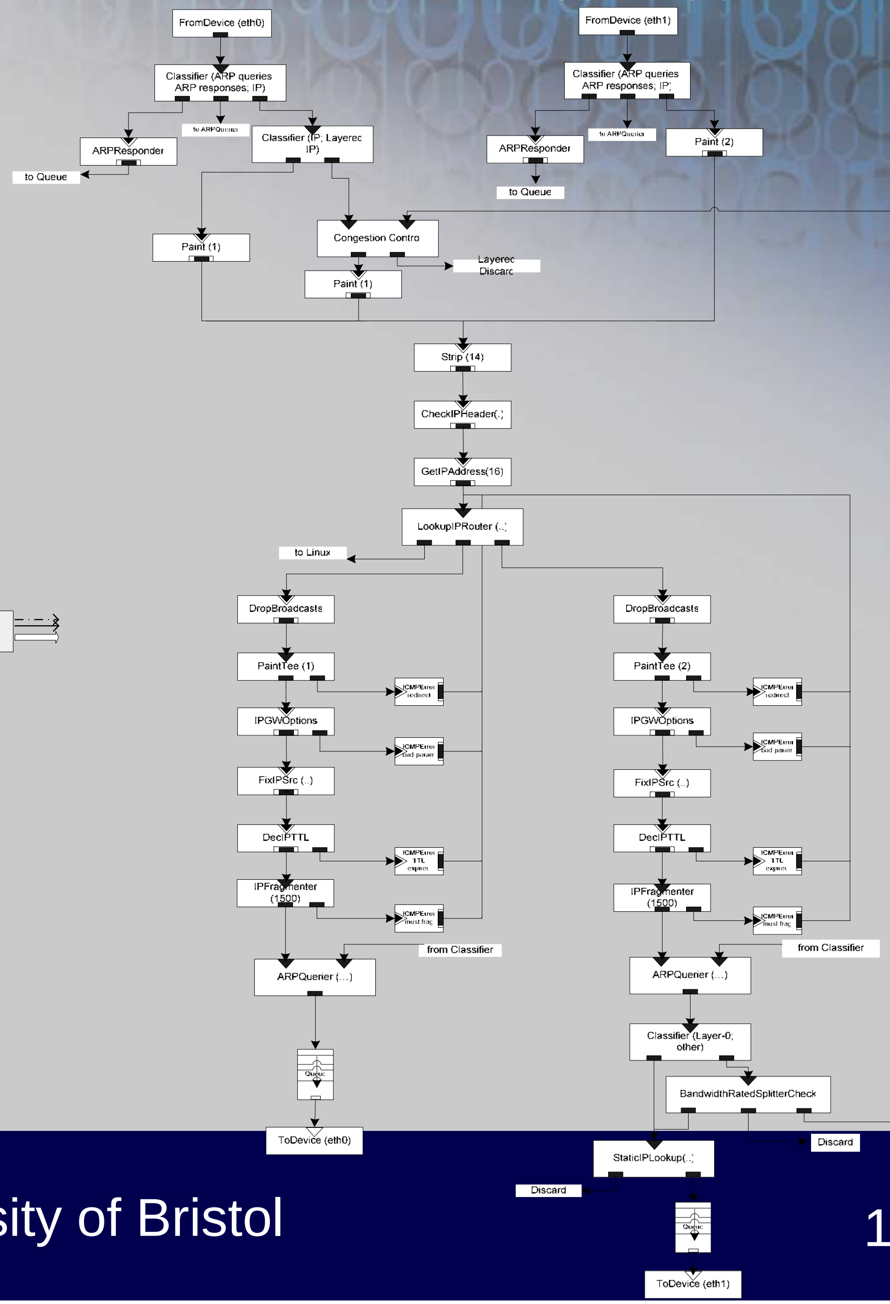
Graph5



Graph6

Layered Video Network Transmission with QoS Support (1)





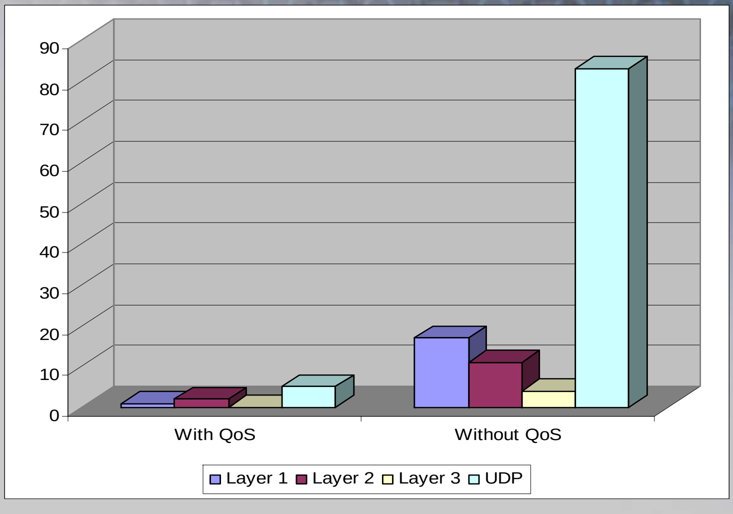
Layered Video Network Transmission with QoS Support (2)

Network Bottleneck Bandwidth: 100KBps

Background Traffic: 75KBps

Video Traffic: 34KBps

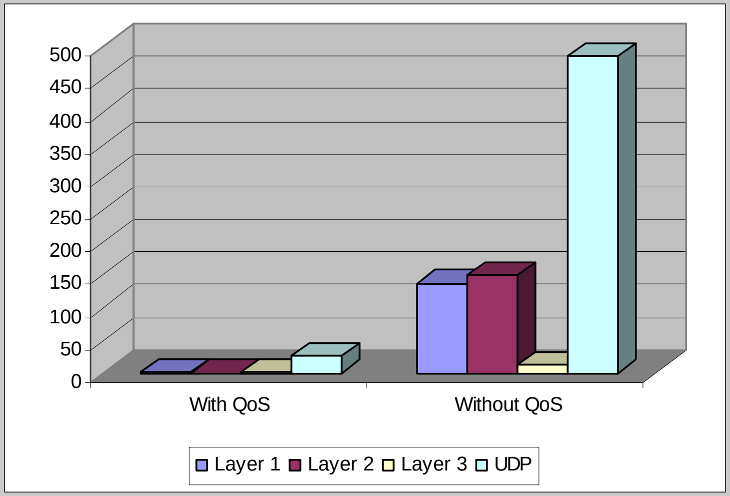
Bandwidth Required: 109KBps



Background Traffic: 85KBps

Video Traffic: 34KBps

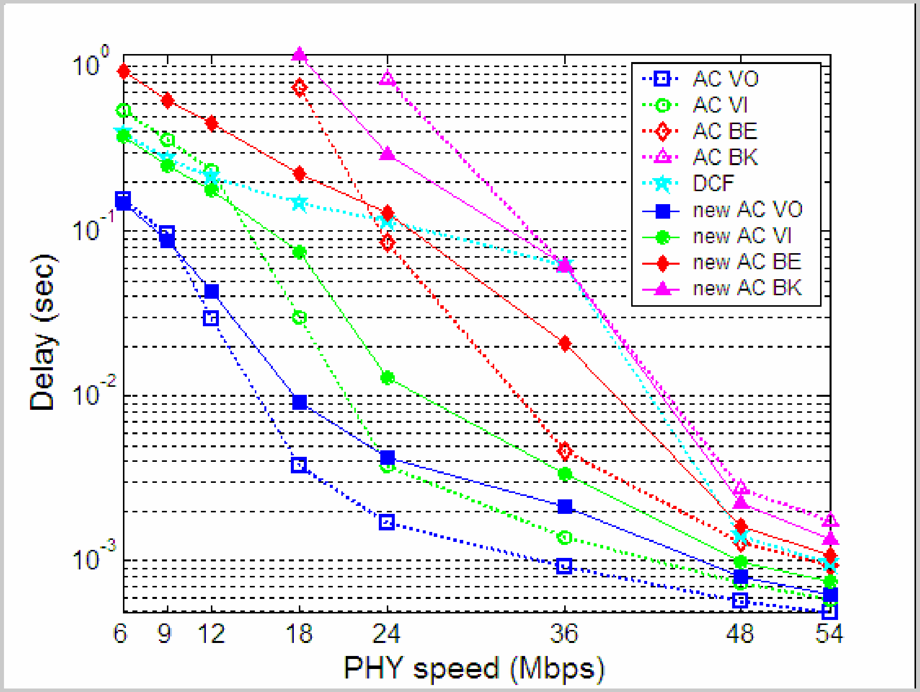
Bandwidth Required: 119KBps

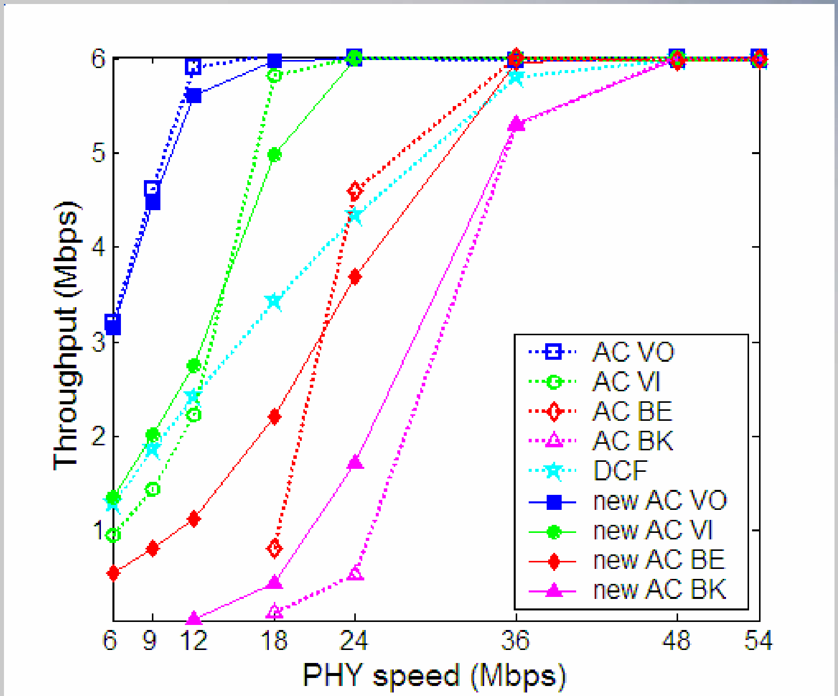


Wireless LAN and QoS

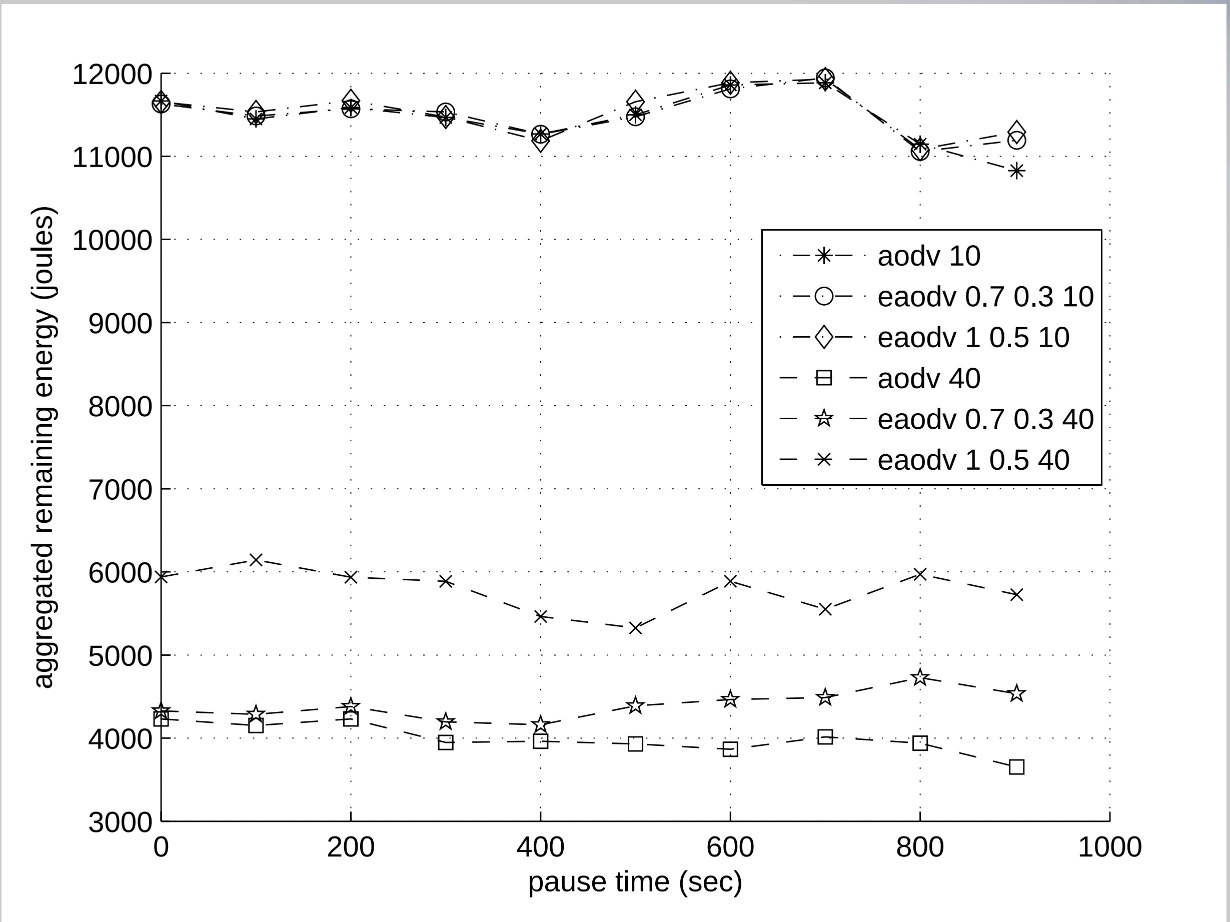
- Many variations on 802.11
- 11n – high rate, short range
  - Depends on multi-hop for coverage
- 11h – centralised resource management
  - Distribute it?
- 11e – QoS for layer 2
  - Maybe…
- Topology - mesh networks

Some 802.11e observations





Some observations on energy

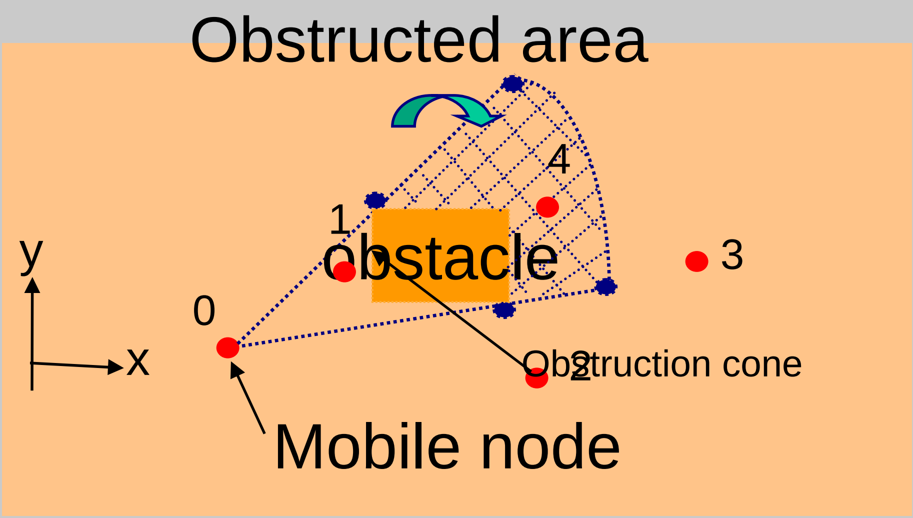


How do nodes move?

- Is random good enough?
- However people move with intention
- Can this be captured?
  - Transportation models
  - Stochastic queueing networks
- Radio propagation?
  - What about obstacles
  - Impact on protocol performance
    - Does it matter?
  - Line-of-sight vs NLOS

Obstacle Mobility Model

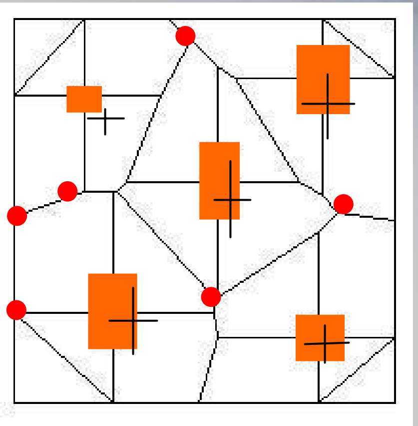
- **Due to Amit Jardosh**
- Transmission obstruction due to obstacle
  - Obstruction cone construction
  - Shaded area, transmission is blocked
- a 2D Model (Now), need a 3D model considering air-to-ground radio propagation.



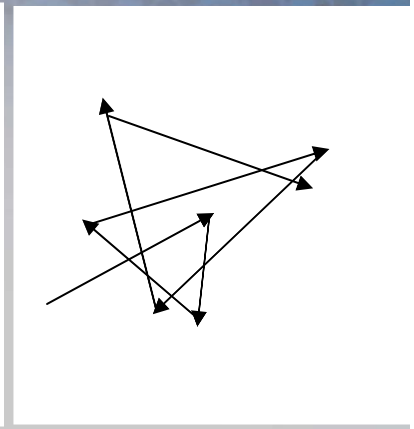
NODE	Message from 0
1	Yes
2	Yes
3	No
4	No

Obstacle Mobility Model

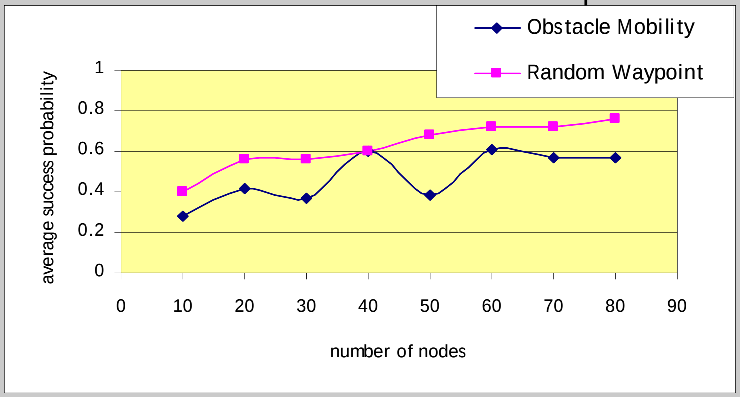
- **Ground Node Movement**
- Urban Scenario (DTC project 2.2)
  - Dimension 400 m x 400 m
  - 5 Obstacles
  - Mobile nodes (10 80), random initial placement
  - Movement path (Voronoi graph)
- Application details
  - 5 source and destination pairs of nodes
  - Packet size: 512 Bytes
  - Packet sending rate: 4 packets/seconds
- Transmission range: 250 m
- Performance Metric
  - Average Success Probability
  - Average Number of Hops



Simulated terrain with movement path (OM model)

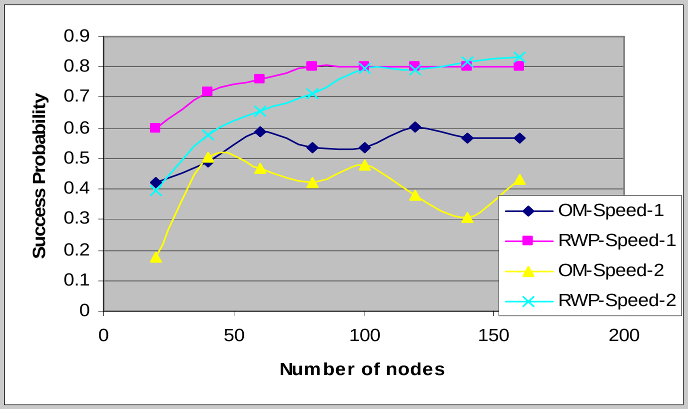


A sample of RWP movement patterns

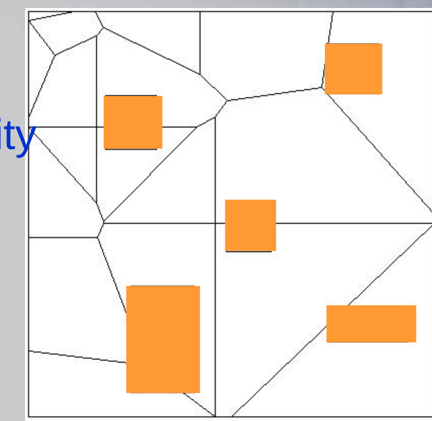


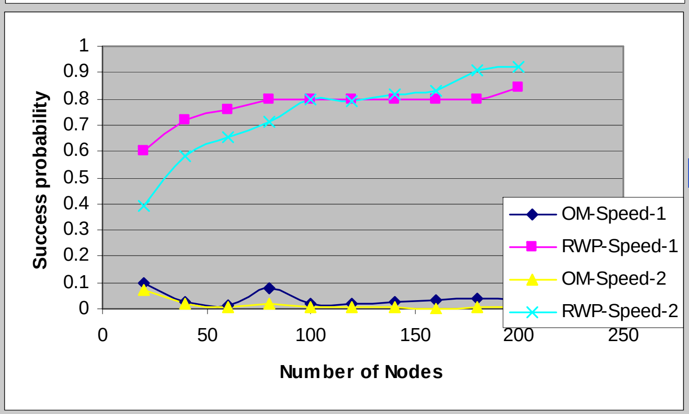
Performance Comparison of OM model and Random Waypoint mobility model

What gets through (or not)

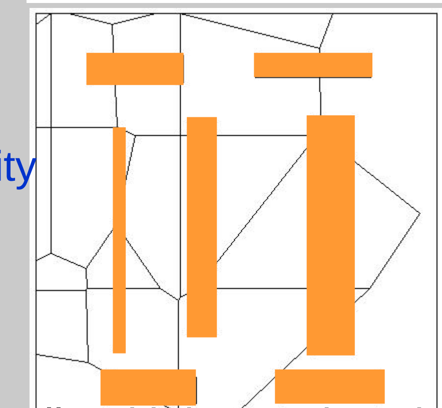


Lower density





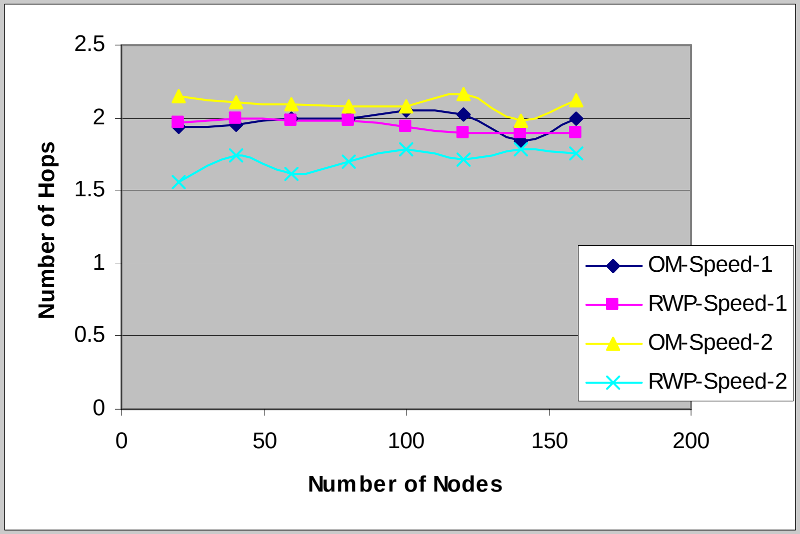
Higher density



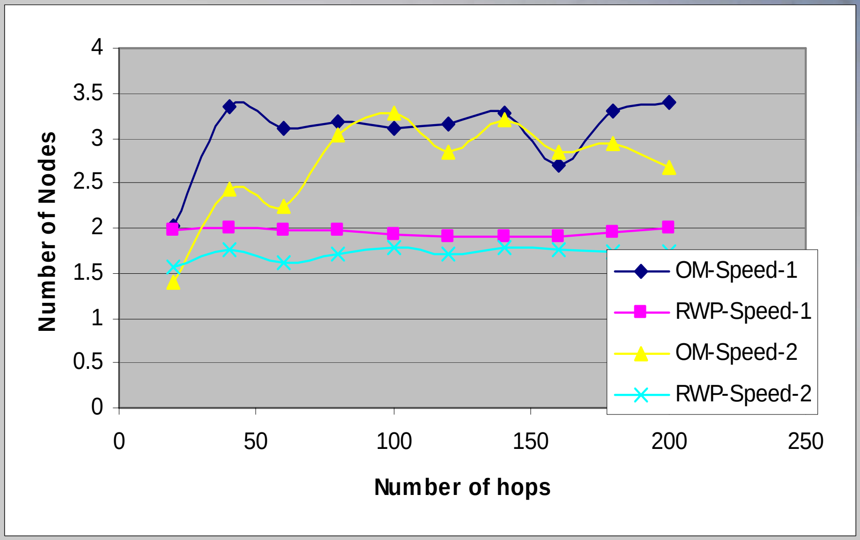
Performance of Success Probability drops dramatically with increasing obstacles coverage – need UAVs

Hops

Lower density



Higher density



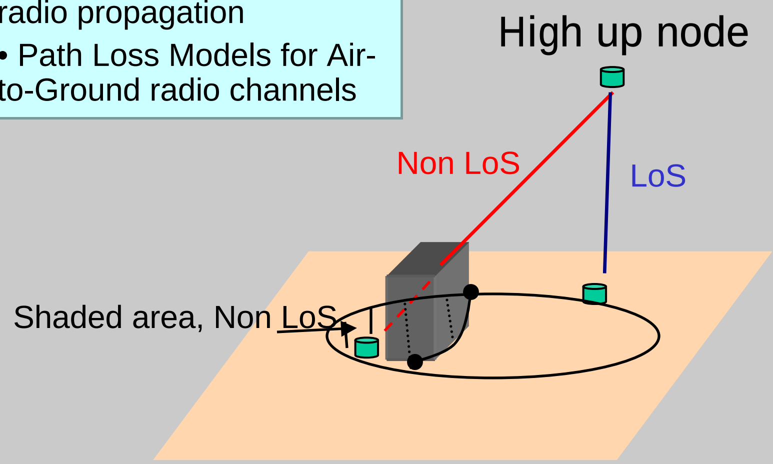
- The number of hops (average) needed for a packet to reach its destination from its corresponding source node increases with increasing obstacle coverage

Modelling Aspect: Radio Propagation Models

- Accurate radio propagation models for various channel types within a multi-level wireless sensor networks
  - Air-to-ground
  - Ground-to-ground

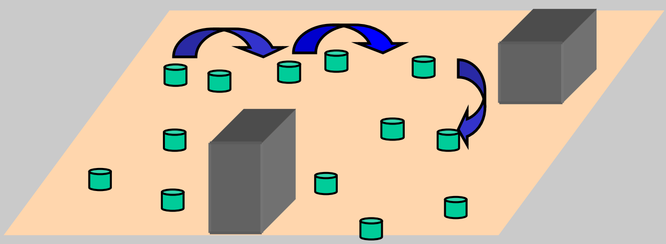
Air-to-ground

- Likelihood of Line-of-Sight for Air-to-Ground radio propagation
- Path Loss Models for Air-to-Ground radio channels



Ground-to-ground

- Path Loss Models for peer-to-peer and multi-hop communications



Modelling Aspect – Others

- The choice of communication strategies/ mechanisms between the ground nodes and elevated nodes affect the suitable type of routing protocol and MAC layer protocol used.

Ground to on-high communication methods

- Fixed and more powerful ground TXs are used
- Direct communication between ground nodes (large number) and elevated nodes, i.e. ground nodes have multiple interfaces

Routing/ MAC layer protocol

- Hierarchical/flat routing protocol
- Efficient MAC protocol to access UAV networks

Node Partitioning

- If fixed and more powerful ground TXs are used to communicate with elevated node, clustering or logical partitioning of the nodes are needed in order to associate nodes with more powerful nodes.

Whoops…

Thank you,

Questions?