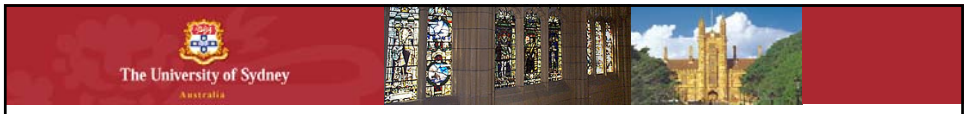

Emerging research in Wireless

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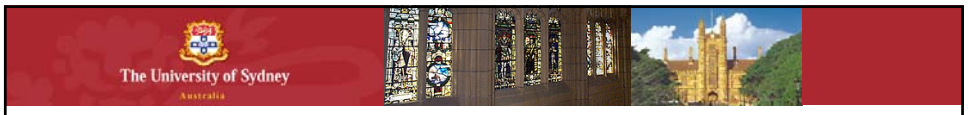
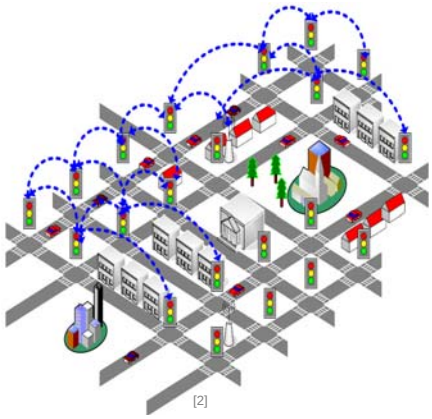


Outline

- Starcomm
  - What we do
  - What we have learned
- Chaotic Networks
  - New collaborative paradigm
  - Where the hard problems are
- Underwater Networks
  - Acoustic and beyond

STARCOMM

- STAR (Smart Traffic and Roads) NICTA and RTA
- STARCOMM
  - communications component
  - cheaper alternative to Telstra 300 bps modems
  - Wi-Mesh an alternative?



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Our approach

- Network layer solutions
  - Radios are interchangeable
  - System can evolve with new radios
- Mulipath routing
- Opportunistic routing
- Measurement driven routing
- Experiments on testbed

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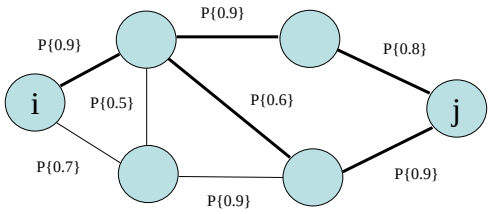
Multipath Routing

- Reliability
  - Find X paths that give Y success probability
  - Optimise overhead to meet requirements

G{V,E}



$$P_{i,j} = \prod_{0}^{n} P_k\{\}$$

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Opportunistic Routing

- Since radio is broadcast media:
  - Many radios can receive packet
  - If packet delivery fails
  - Other node can step in and forward
  - No need to start from scratch

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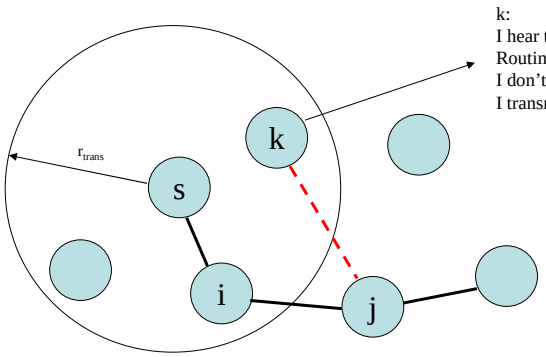
Opportunistic Routing



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Measurement Driven Routing

- Some routers act as monitors
  - Graph view of network from routing tables *and* inspected headers
  - If routing path inconsistent with tables react
    - Quickly isolate problem nodes (table updates)
    - Raise alarm

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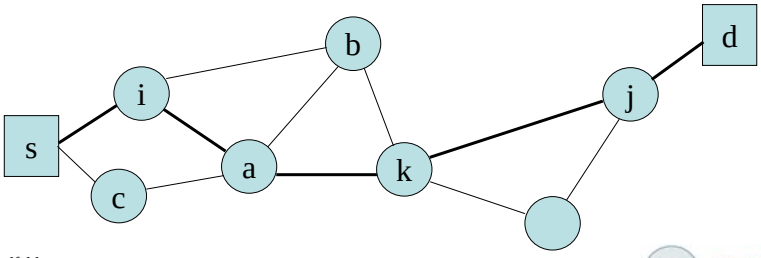
Measurement Driven Routing

Monitor k:

Tables say path source to dest. {s,i,a,k,j,d}
Packet header TTL indicate 4 hops
Path is probably {s,i,b,a,k}
Update or isolate i



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Testbed

- Currently 8 nodes in Redfern
- We are deploying a second testbed (probably Liverpool) in the near future
- Used to experiment with the theoretical models we build

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Testbed

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Channel contention

- Our measurements ~60 APs in one intersection, ~400 wireless nodes at one time (many NOKIA)
- Seminal paper: MOBICOM 2005, “Self-Management in Chaotic Wireless Deployments”, Akella et al.

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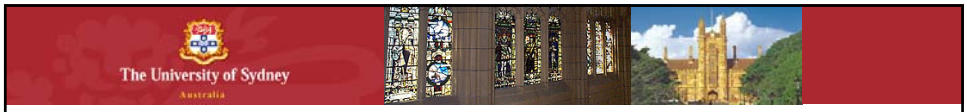
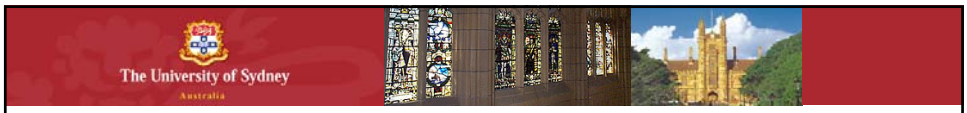


Channel contention

- What does this mean?
  - Many more APs than channels
  - Competition for resources
- In effect, 802.11 starts behaving badly
  - Unreliable service
  - High delay and BW variability
  - QoS sensitive services? Forget it.
- User perceived services will suffer greatly!
- *S. Manitpornsut and B. Landfeldt, On the Performance of IEEE 802.11 QoS Mechanisms under Spectrum Competition, In Proc. IWCMC 2006, Montreal Canada 2006*



Does this mean WLAN is bad?

- No, but it means we have to rethink how we build WLAN in public settings
- Fundamental problem unlicensed spectrum
  - Chaotic deployments need to be *managed, but by whom?*
  - *Many owners, no single administrator*
  - *Most owners agnostic*
- NETWORK NEEDS TO BECOME SELF MANAGING (NEW PARADIGM)

Hard Problems

- Channel allocation schemes
  - APs monitor environment
  - Algorithms determine optimum allocation to minimise overlap
- Power management
  - Spatial separation
  - If I can do with lower data rate, lower power (modulation rate), we can co-exist
  - Problem: do I still cover the area I want to cover?

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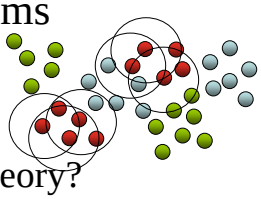
Hard Problems

- Distributed collaborative algorithms
  - Need to be dynamic
  - Computationally Tractable?
  - Reinforce with standards? Game theory?



"Game Theoretic Approach for Load Balancing in Computational Grids", R. Subrata, A. Zomaya and B. Landfeldt, IEEE Transactions on Parallel and Distributed Systems, in Press

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Underwater communications

- Who would be interested?
- Natural sciences
  - Monitoring of underwater ecosystems, marine life behaviour, environmental conditions
- Fisheries
- Structure monitoring
- Defense

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Acoustic networks

- Acoustic properties quite well understood, challenges in MAC and above
- Properties
  - Lots of background noise
  - Varying propagation paths and characteristics
  - Long delay
  - Low data rates
  - Varying temperature, thermoclines…..
- Due to extreme properties, like no network on land

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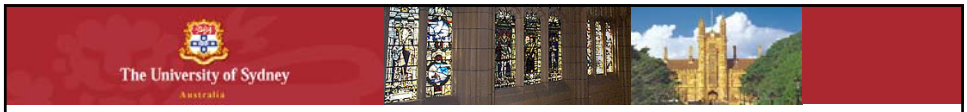

Network Issues

- MAC
  - FDMA - Not enough BW in UW channel
  - TDMA - Too much Doppler, ISI, guard slots needed, poor performance
  - Contention based (CSMA), Long delays, collisions likely - Low Utilisation
  - CDMA - can cope with Doppler and delay much better but receiver complex (filtering due to poor channel conditions)

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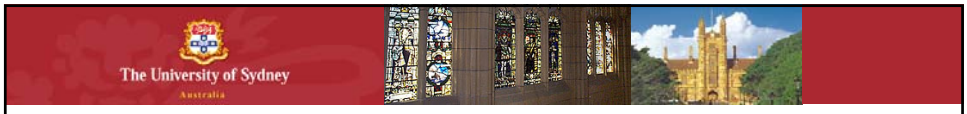

Network Issues

- Network Layer
  - Algorithms for latency bounds
    - Time critical applications
    - Delay tolerant applications
  - Fault tolerant routing
    - Varying channel characteristics
    - Limited BW, flooding?
  - Mobility, UAVs, gliders, drifters etc.

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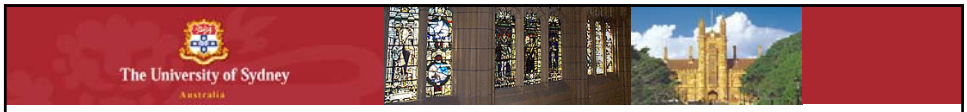
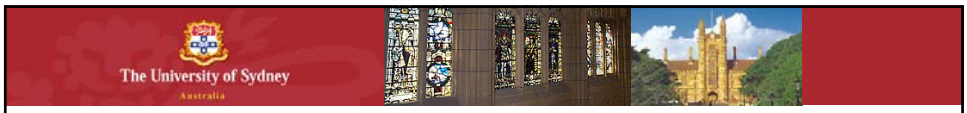


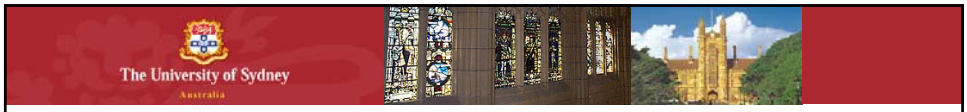
Network Issues

- Transport layer
  - Flow control
    - High delay variance RTT based (TCP) not good
  - Packet loss highly varying
    - ARQ/FEC?
- Cross layer solutions attractive



In Network processing

- Since communication channel limiting
  - Data management important
    - Aggregation
    - Pre-processing
  - Efficient algorithms necessary
    - Application specific
- Ongoing work at USYD and NICTA



Conclusion

- Wireless research is branching out
- There are many new and challenging issues involved in new ways of building wireless systems, new usages etc.
- We gave two very different examples of emerging research areas
- New ways of thinking are required

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