



University of York Communications Research

Alister Burr

alister@ohm.york.ac.uk

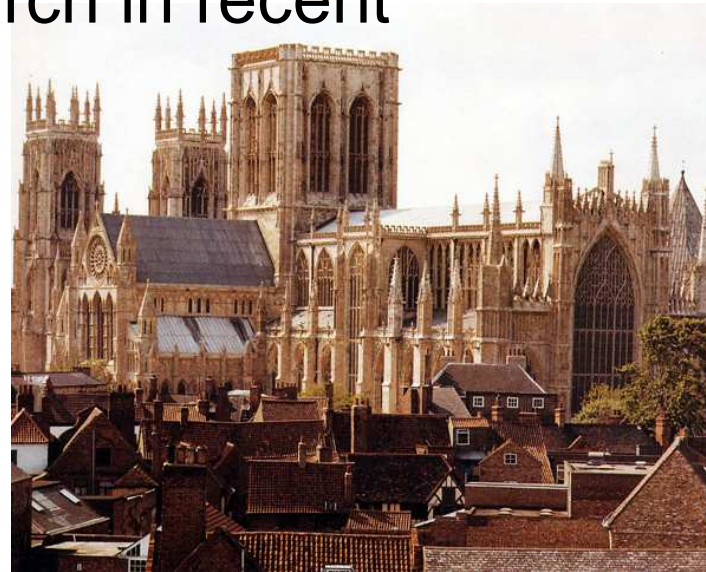




- University of York and Dept of Electronics
- Communications Research Group
 - overview and main research areas
- Proposed “China Bridges” projects
 - Self-organising wireless networks
 - Spatio-temporal precoding for 4G
 - Network soft coded modulation
- Existing research outcomes
 - *for exploitation*



- Located approx 300 km north of London
- Founded 1963
- Approx 11000 students in 30 depts
- Ranked 11th in U.K, 74th in the world*
- Ranked 8th for research in recent RAE+



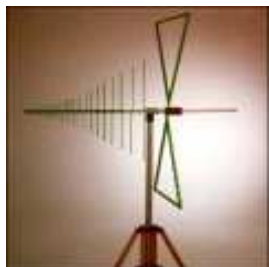
*The Times; +The Guardian



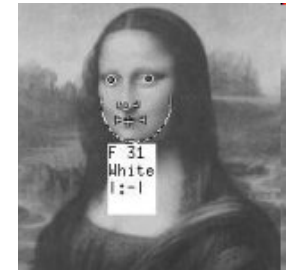
- *Founded 1979*
- *Approx 35 academic staff; 500 students inc. 90 PhD*
- *Ranked 9th in U.K.*

Research Groups

- “Physical Layer”
 - Applied Electromagnetism
 - Nanotechnology and Electron Optics
 - RF and optical systems



- Intelligent Systems
 - Bio-inspired architectures
 - Biological systems
 - Visual Systems



- Audio Lab
 - Sound perception and synthesis
 - Music processing
 - Acoustic modelling
 - “Real Virtuality”



- **Communications**



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Academic/research staff



Tim Tozer (Group leader)

Alister Burr



Rodrigo de Lamare

David Grace



Paul Mitchell

Dave Pearce



John Thornton

Yuriy Zakharov



+ ~30 research students

Research activities

- *High Altitude Platforms (HAPs)*
- *Antennas for satellite/HAPs*
- *Wireless Sensor Networks*
- *TCP/IP for wireless*
- *Cognitive Communications*
- *Turbo codes and iterative techniques*
- *MIMO and array processing*
- *Signal processing implementation*



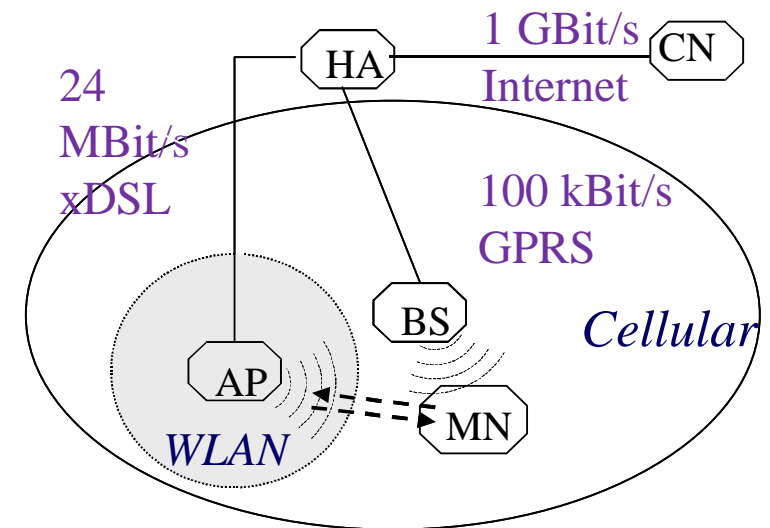
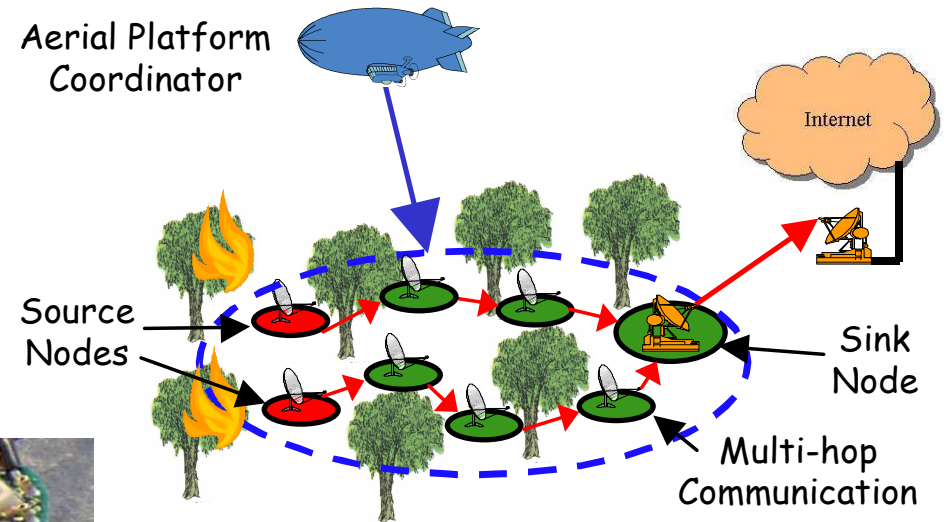
- High Altitude Platforms
 - quasi-stationary stratospheric aircraft carrying communications payload
 - York has extensive EU and industrial funding to develop comms systems
 - *HeliNET, Capanina, UseHAAS, StratXX, COST 297*
- Scanning SHF antennas for satellite/HAPs
 - using lens reflector antenna
 - e.g broadband for trains
 - part-funded by ESA





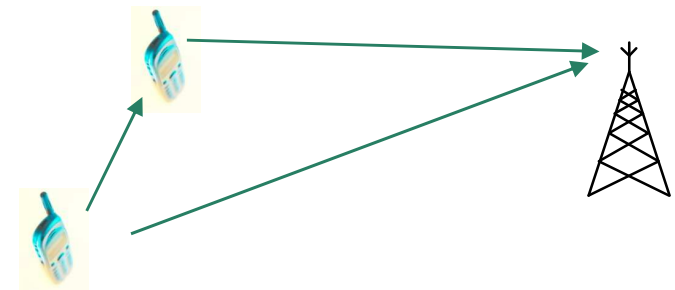
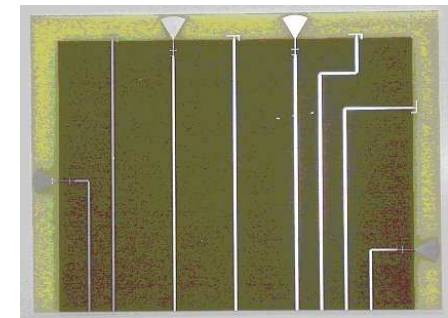
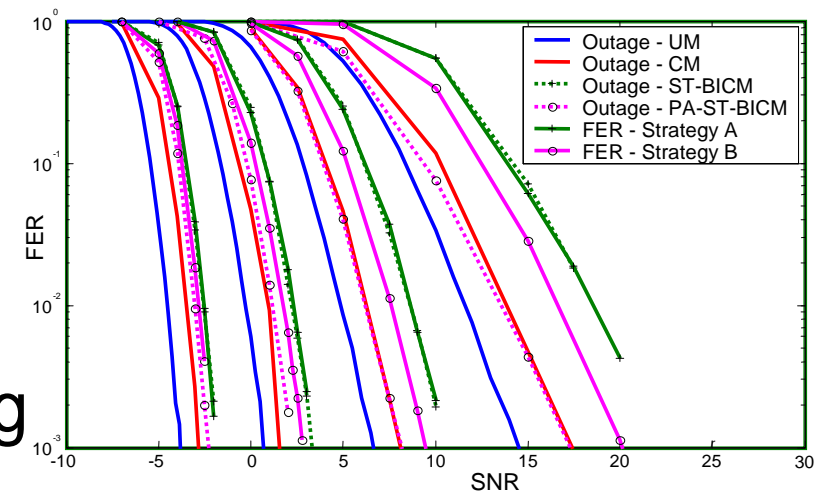
- WSN research at York:
 - Medium access control
 - Multi-hop routing
 - Use of HAPs
 - Hardware implementation

- TCP-IP in wireless:
 - Vertical handover
 - Multicast in wireless networks





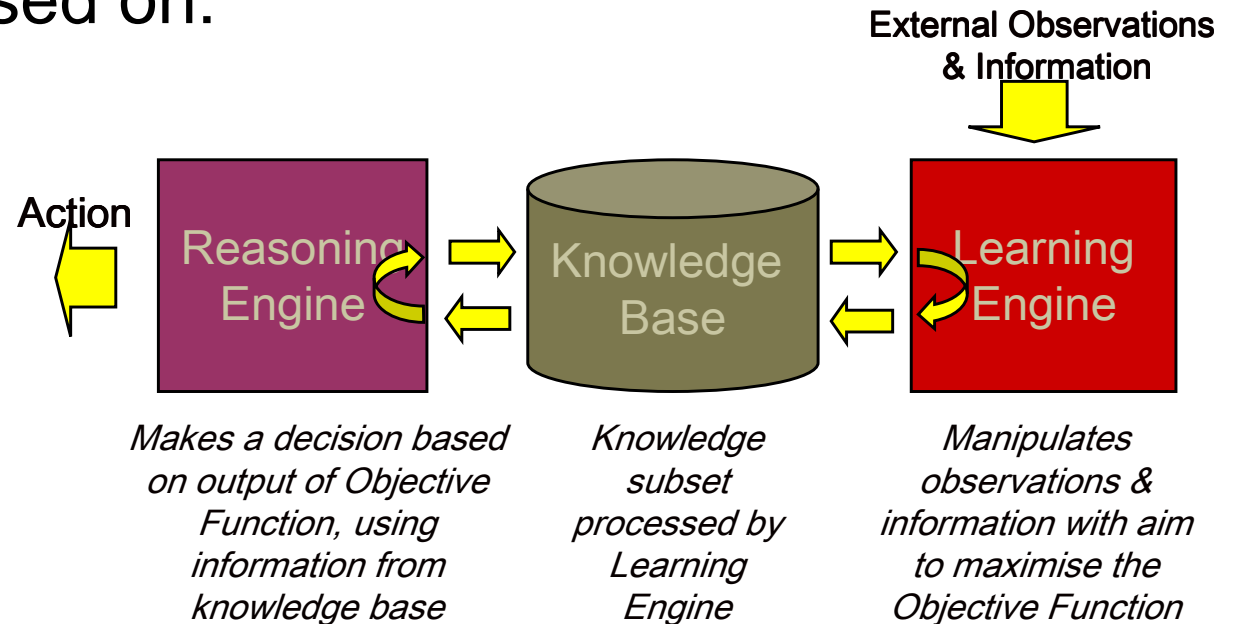
- Statistical signal processing
 - Detection and estimation theory
 - Reduced rank methods
 - FPGA implementation
- Turbo-codes and iterative processing
 - Turbo and LDPC codes
 - Iterative interference cancellation
- MIMO
 - MIMO Channel modelling
 - Antennas for MIMO
 - Adaptive MIMO-OFDM(A)
- Cooperative communications and relaying





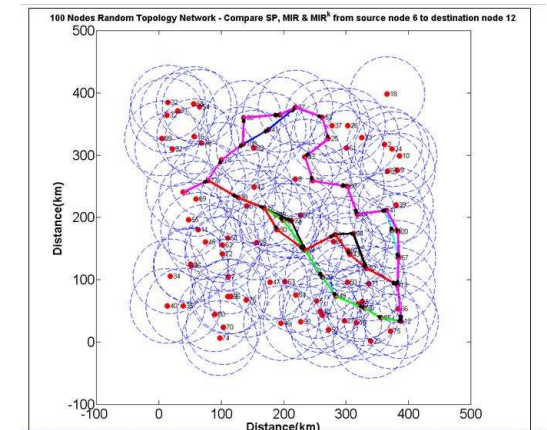
- York vision of cognitive communications exploits distributed artificial intelligence, based on:

- reinforcement learning
- game theory
- multi-agent systems
- information theoretic bounds



- Research embraces:

- distributed bandwidth assignment and spectrum sharing
- minimum impact routing
- cognitive multicast
- reduced complexity searching





- U.K. Ministry of Defence

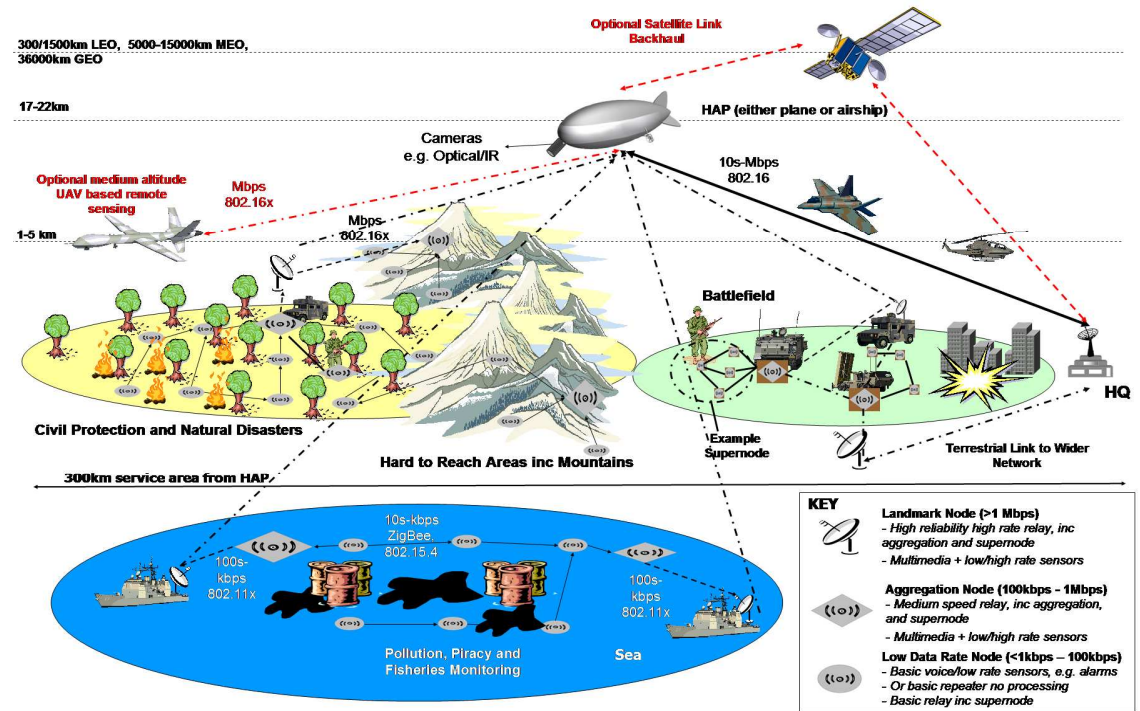
“Cognitive Routing for Tactical Ad Hoc Networks”

- routing in heterogeneous, hierarchical networks
- “supernode” concept

- Worldwide Universities Network (WUN)
COGCOM consortium:

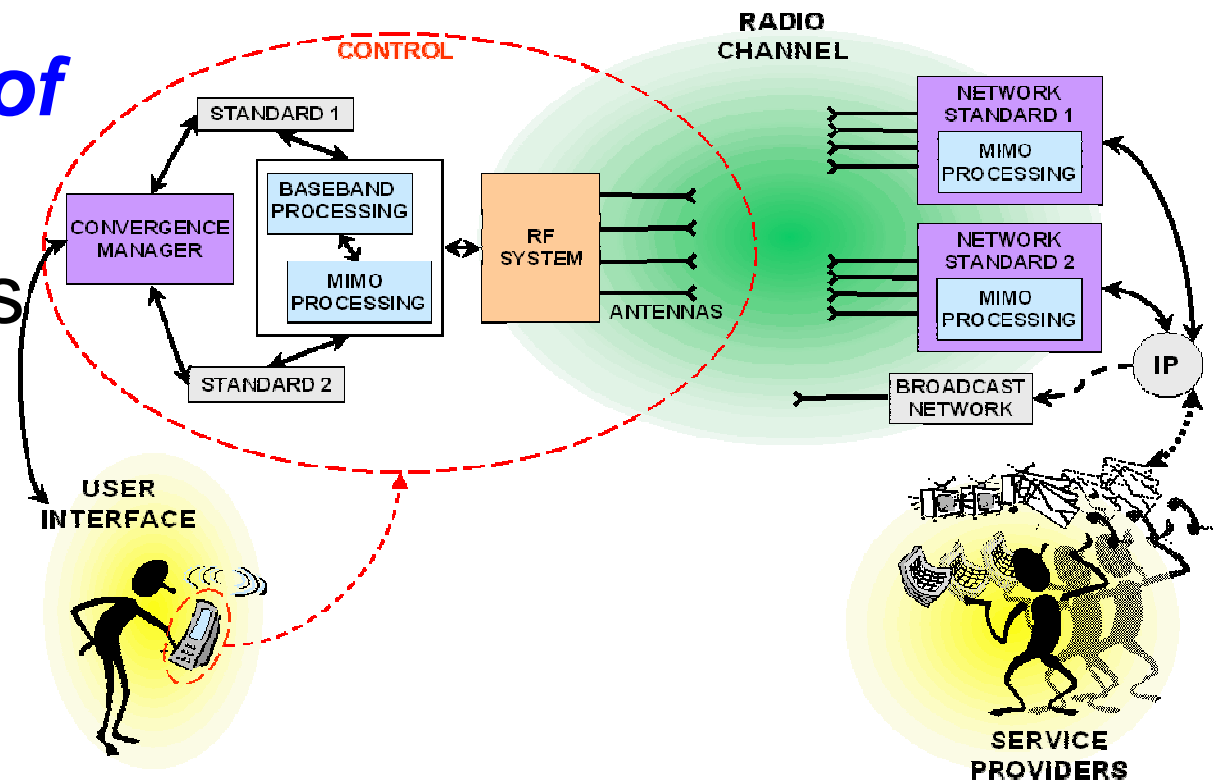
www.wun-cogcom.org

- 4 UK, 6 other Europe, 4 US, 3 China, 3 ANZ, 4 industry





- **FL**exible **cO**nvergence of **W**ireless **S**tandards and services
- **Simultaneous use of standards**
- Technical challenges of a multi-standard terminal
 - antennas
 - MIMO-enabled convergence
 - Core network issues



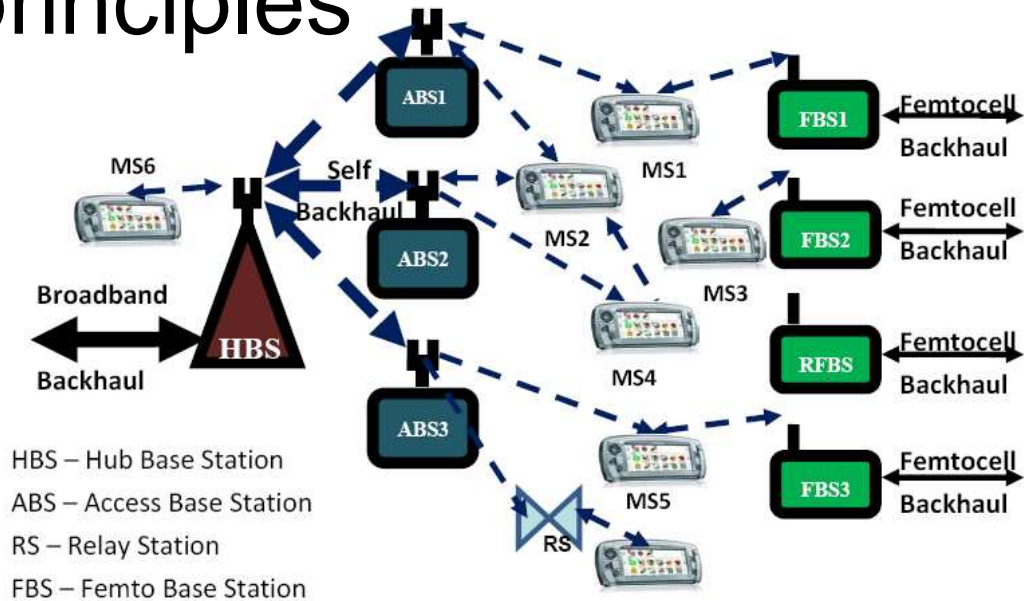


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...exploiting cognitive principles

- To provide extremely high data bandwidth/km², 4G networks will need wireless backhaul
 - creates wireless mesh access network
 - centralised routing and resource allocation is inefficient
- Requires ***self-organising network*** exploiting distributed intelligence
 - for both routing and channel allocation
 - exploit cooperation of both terminals and infrastructure



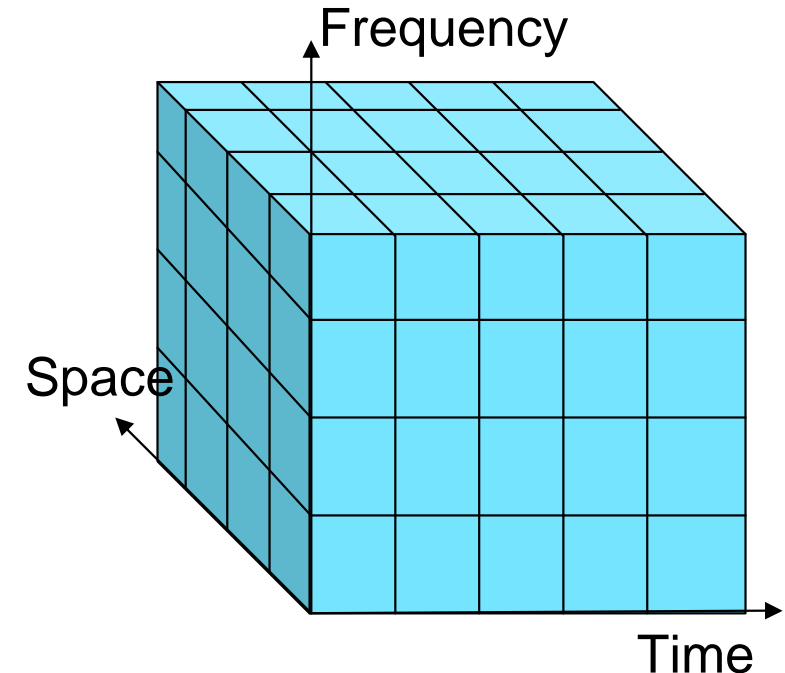


- ***York contribution:***
 - Cognitive algorithms for optimum routing and resource allocation
 - Virtual- and network-MIMO techniques
 - Information-theoretic capacity bounds
- ***Partner capabilities sought:***
 - Establishment of large-scale test-bed
 - Antennas and RF systems
 - Higher layer protocols for service provision
- ***Related current projects/partners***
 - WUN-COGCOM
 - European BuNGee project



Spatio-temporal precoding for 4G

- 4G wireless standards (LTE-Adv, WiMAX) use **spatial precoding** for MIMO transmission
- OFDMA is effectively a multi-user temporal precoding scheme
 - CDMA, MC-CDMA, OFCDM are alternatives
- York has developed framework for joint **multi-user spatio-temporal precoding**
 - based on tensor notation
 - allows use of tensor-based methods
 - exploits MU-MIMO benefits
- Allows adaptation of transmitted signal
 - also adaptation to the quality of CSI, with limited feedback

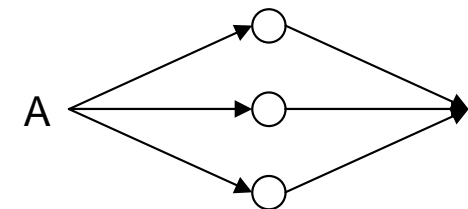
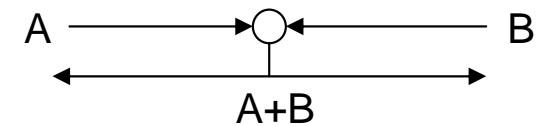
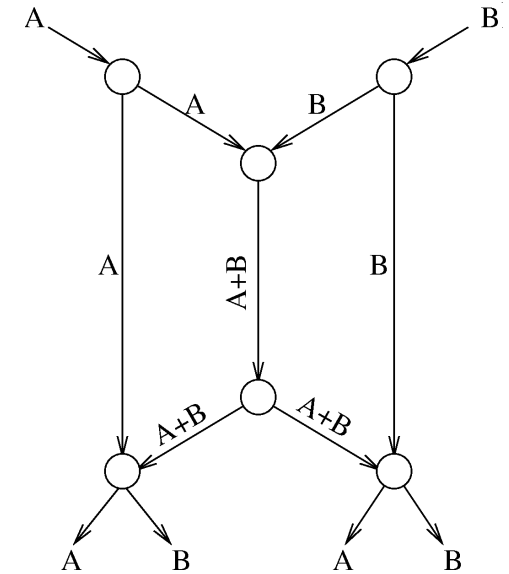




- ***York contribution:***
 - Precoding framework
 - Signal processing and coding expertise
 - MU-MIMO-OFDM channel modelling
- ***Partner capabilities sought:***
 - Multi-user link testbed
 - Hardware implementation
- ***Related projects/partners***
 - COST 2100
 - BT/Pace
 - UK research council submission



- **Network coding** allows data processing at intermediate nodes
 - can increase throughput, e.g. for multicast
 - also 2 way relaying
 - allows use of relay without reducing throughput
- In wireless networks
 - must allow for broadcast nature of channel,
 - and for its unreliability
- Forward soft information, rather than bits
 - cf message passing in turbo/LDPC decoder
- Applicable to multiple parallel relays
 - exploit **distributed source coding** (Slepian-Wolf)





- Preliminary work has indicated practical schemes for the wireless 2-way relay channel
 - In addition approaches for the multiple relay channel are under development
- ***Proposed joint project***
 - further define these schemes using simulation
 - then develop practical implementations
- ***Applications***
 - Wireless mesh access networks (using relaying/wireless backhaul)
 - “Internet of things”
 - Wireless sensor networks



- ***York contribution***

- Theoretical principles
- Initial schemes

- ***Partner capability sought***

- Further theoretical contribution, especially in distributed source coding
- Hardware implementation and testbed

- ***Related projects/partners***

- University of Southampton; Czech Technical University; JAIST/University of Oulu
- Proposed COST action



- DCD (Dichotomous Co-ordinate Descent) algorithm (patented)
 - “Hardware friendly” multiplication-free iterative solution of linear equations
 - e.g. MIMO/multiuser detection, adaptive filters
- A-ML-DFE (Approximate maximum likelihood decision feedback equaliser) (patented)
- Differential spatial multiplexing (not yet patented)
 - spatial multiplexing scheme that does not require CSI at receiver

