Institut
Mines-Telecom

IMT Activities on 5G

Marceau Coupechoux

Workshop on Modeling, Optimization and Control in 5G Networks
Paris, 7 Sept. 2015

Introduction

- Again a vision of 5G !?

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- Again a vision of 5G !?
- No: only 2 slides...

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- A detailed and accurate list of research issues ?

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- No: a tentative classification of key (buzz?) words.

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- Can I ask questions ?

Introduction

- Again a vision of 5G !?
- No: only 2 slides...
- A detailed and accurate list of research issues ?
- No: a tentative classification of key (buzz?) words.
- Can I ask questions ?
- No: except on load balancing in HetNets and matching games for user association.

Images

- All images are taken from papers published by IMT researchers

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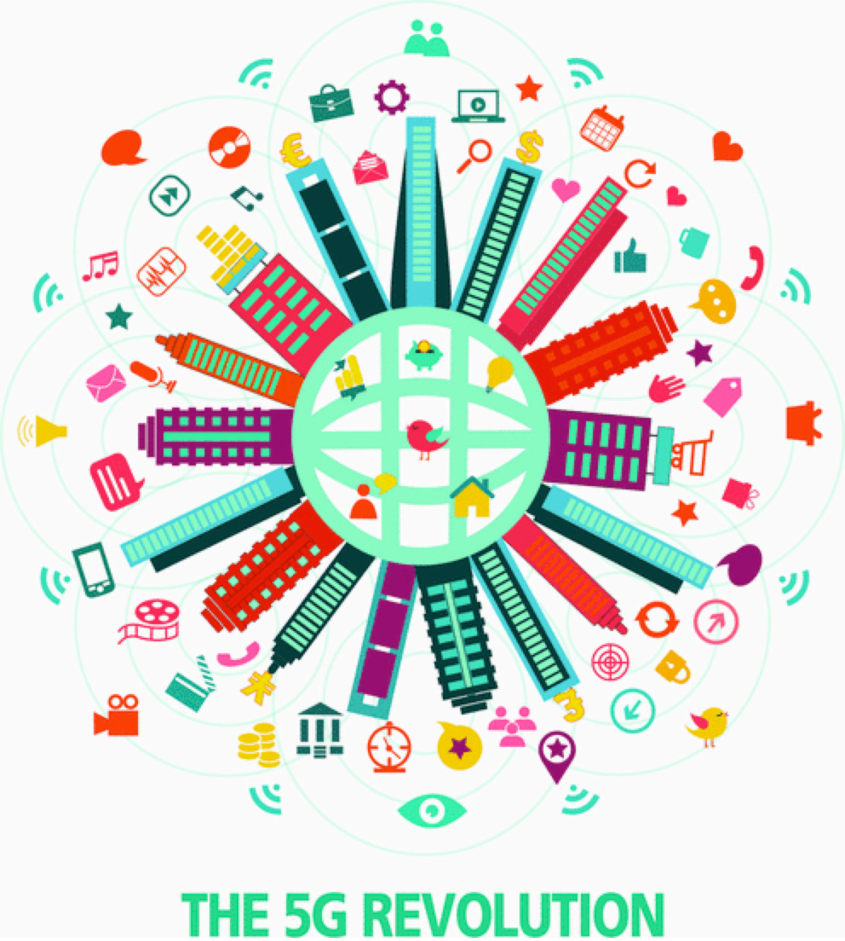
- Including this one:



Source: Di Taranto, R.; Muppirisetty, S.; Raulefs, R.; Slock, D.; Svensson, T.; Wymeersch, H., "Location-Aware Communications for 5G Networks: How location information can improve scalability, latency, and robustness of 5G," in Signal Processing Magazine, IEEE , vol.31, no.6, pp.102-112, Nov. 2014

Some 5G Challenges

- An increasing demand (capacity, data rate, latency requirements)
- A high heterogeneity (terminals, equipments, technologies)
- A massive connectivity (support for machine-type com., IoT)
- A wide range of applications (QoS, QoE requirements)
- The need for fossile energy consumption reduction
- The need for security and privacy

Some 5G Challenges

HIGH PERFORMANCES

- Densify
- Use more spectrum
- Increase spectral efficiency
- Model systems and evaluate performance

EFFICIENT RESOURCE ALLOCATION

- Manage interference
- Manage spectrum
- Save energy
- Manage traffic and mobility

MASSIVE CONNECTIVITY

- Support MTC and IoT
- Support Intelligent Transportation Systems
- Support Public Safety applications

QoE AND SECURITY

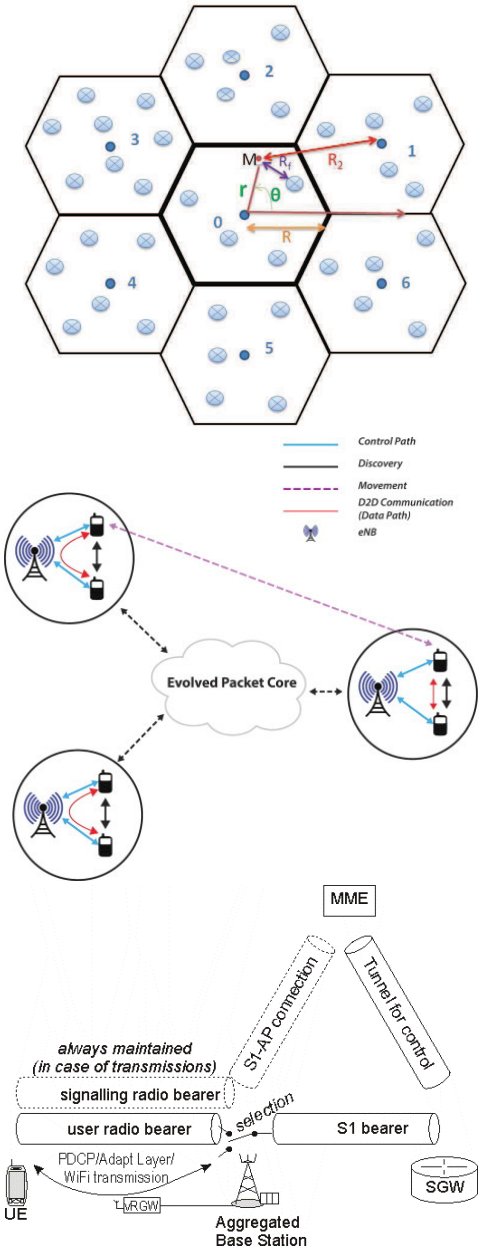
- Improve video QoE
- Ensure efficient content diffusion
- Ensure security and privacy

FLEXIBLE AND LOW COST NETWORK MANAGEMENT

- Virtualized and cloud based networks
- Decentralized self-organized networks
- Fixed-mobile convergence
- Infrastructure sharing

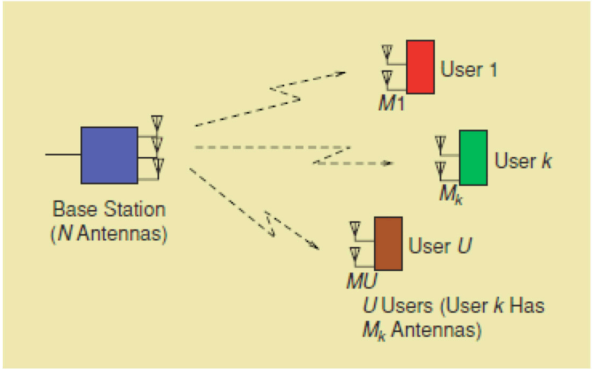
IMT Activities on: Densification

- **HetNets**: impacts on capacity, coverage, energy efficiency, impact of mobility.
- **Multi-RAT**: joint radio resource management schemes for LTE/WiFi networks. Algorithms to deliver Mobile TV in a LTE/DVB hybrid network. 802.11s-LTE interworking. Tight coupling LTE/WiFi architectures for offloading.
- **Relays**: relay placement optimization, relay power optimization, relay selection, mobile relay performance evaluation, cooperative relay optimal scheduling, full duplex relays.
- **D2D**: online matching of D2D users, use of mobility and community structure for large scale dissemination in D2D networks.



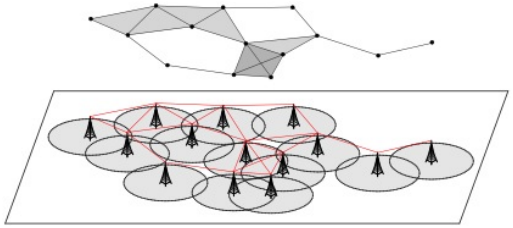
IMT Activities on: Improved Spectral Efficiency

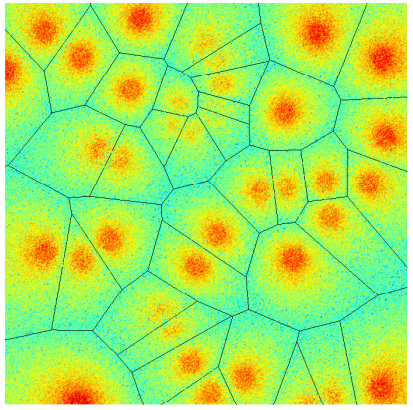
- **MIMO**: MU, Massive, Network MIMO. Precoder design, performance evaluation under imperfect CSIT. Feedback mechanisms (inc. based on D2D communications). User selection schemes for MU-MIMO. Interference reduction techniques. Channel estimation schemes to tackle the pilot contamination problem in massive MIMO. **Performance/complexity** analysis. Low complexity decoders.
- **Network Information theory** for the cognitive interference channel, the half-duplex relay channel.
- **Decentralized optimization** and decision making across devices.
- **Lattice codes** for interference reduction, **network coding**.



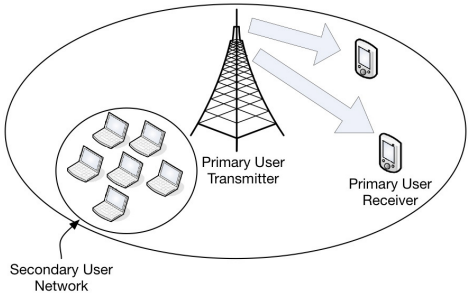
IMT Activities on: Performance Evaluation

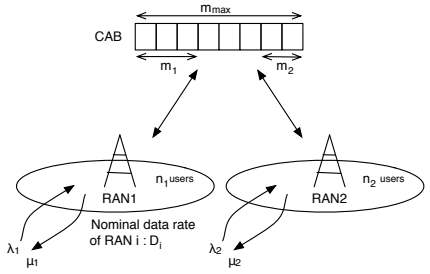
- **Stochastic Geometry and Simplicial Homology**: spatial models for performance evaluation, dimensioning, planning of future cellular technologies (CoMP, massive MIMO, SIC, NOMA, mmW, relays)
- **Traffic and mobility studies**: impact of beamforming, CoMP, HetNets on capacity and user throughputs (from a queueing theory point of view).
- **OpenAirInterface**: a platform for 5G research on M2M, C-RAN, HetNets, D2D, dynamic spectrum access, SDN, latency analysis.

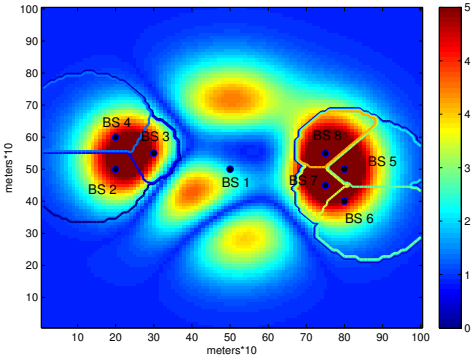




IMT Activities on: Interference and Spectrum Management

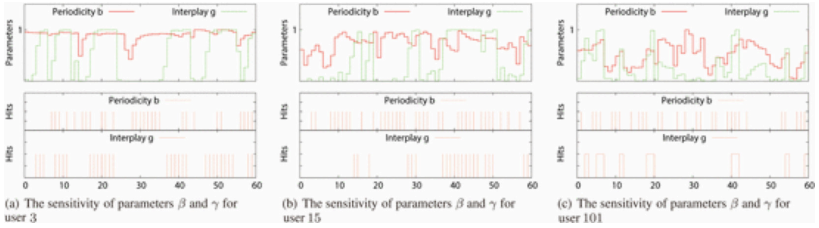


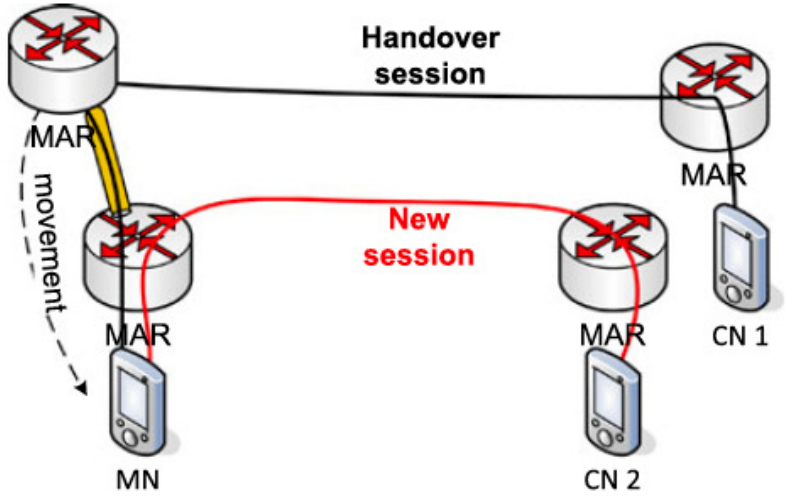




- **Interference coordination** (ICIC) and load balancing SON schemes in HetNets. User association schemes with service differentiation.
- MAB algorithms for **opportunistic spectrum access**. Joint power and sensing strategies for interweave / underlay cognitive radio under imperfect CSIT. CR for VANETs. Surveillance strategies against malicious PUs. Collaborative sensing. TV **white space** trials.
- Inter-operators **spectrum sharing** rules, algorithm design for Licensed Shared Access, Carrier Aggregation (CA), inter-RAT CA.

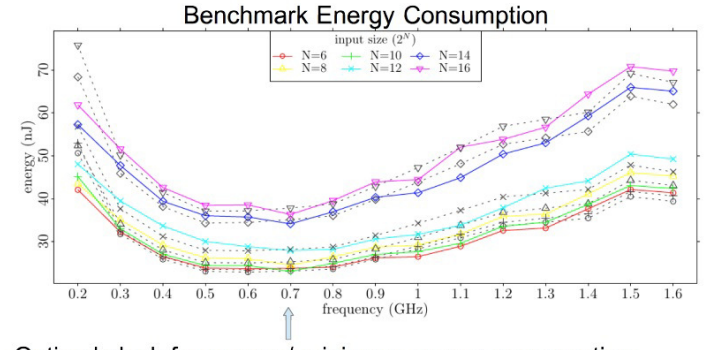
IMT Activities on: Traffic and Mobility Management

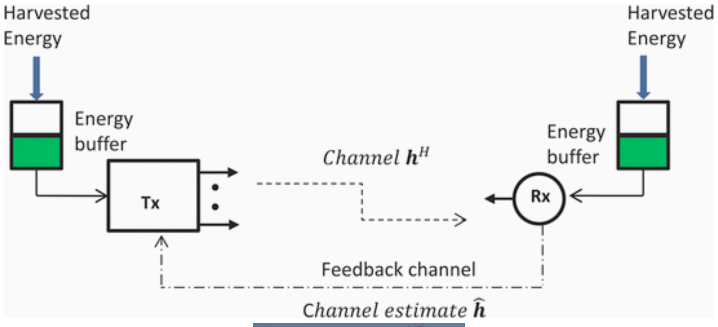


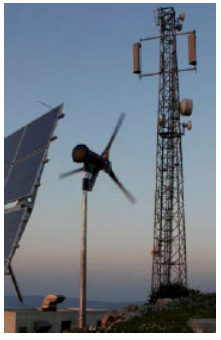


- **User location prediction** based on social inter-play and user periodic behaviors (from network traces).
- **Mobility management**: Hybrid centralized-distributed mobility management (DMM) to overcome the drawbacks of DMM and PMIPv6. Performance evaluation of Dynamic Mobility Anchoring (DMA) and PMIP.
- An architecture to manage **delay-tolerant** users and an algorithm to decide when to trigger the download.

IMT Activities on: Energy Saving

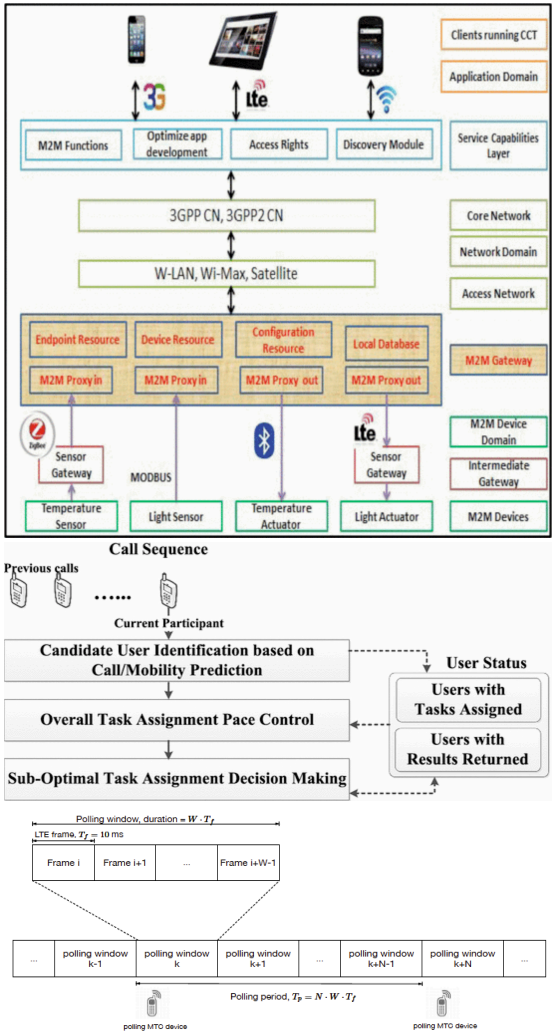






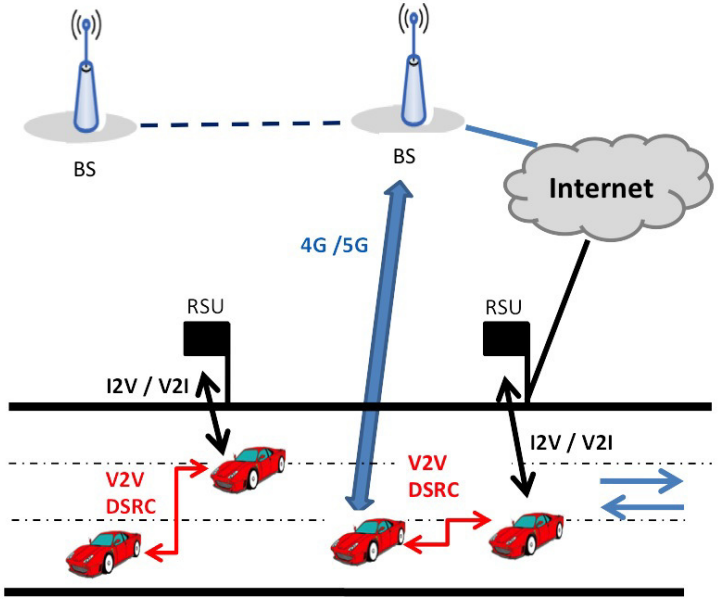
- Energy optimization of **mobile devices**. Modeling of device energy consumption (platforms).
- **Base station switch off mechanisms** using simplicial homology. Transmit power reduction impact on capacity and coverage. Online controller for optimizing BS sleep modes. Study of the trade-off between user QoE and energy saving. Cell breathing approaches in HetNets. Effects on EM exposure.
- Analysis and optimization of **energy harvesting** communication systems and hybrid base stations.

IMT Activities on: Machine-Type-Communications

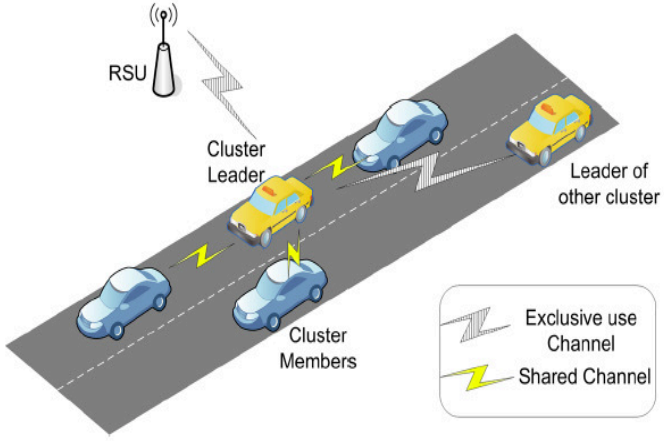


- **Architectures**: M2M device management, IoT architectures for health-care services in smart homes or for smart cities. Fog computing architecture for IoT and M2M. Service discovery architectures.
- **Access**: packet aggregation, MAC, power control, resource allocation mechanisms for **massive random access**. Contention-based access using MU-MIMO at the BS. M2M traffic modeling. Modeling, performance evaluation, PHY and MAC optimization of bursty transmissions (short packets, impulsive interference).
- **Crowdsensing**: an algorithm to reduce energy consumption in data transfer by optimizing task assignment and data collection while considering privacy issues.

IMT Activities on: Intelligent Transportation Systems

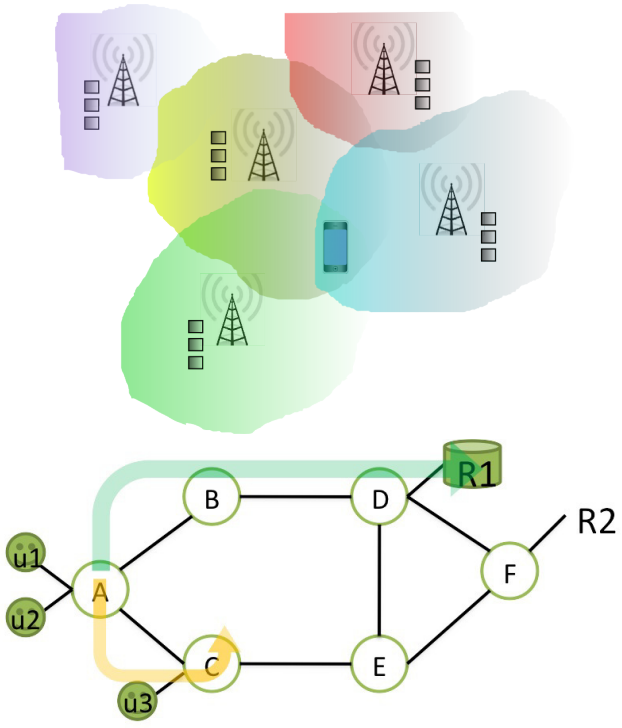


RSU: Road Side Unit, DSRC: Dedicated Short Range Com. I2V: Infra to Vehicle



- **ITS-5G cooperation**: Cooperative ITS-5G gateway, interface selection algorithms. Load balancing techniques. Cellular network offloading algorithms through VANETs. A LTE-direct broadcast mechanism for periodic vehicular safety communications. D2D for safety applications.
- **iTETRIS**: A modular simulation platform for the large scale evaluation of cooperative ITS applications.
- **Architectures**: Storage placement on the 5G edge nodes (LTE or WiFi or DSRC/ITSG5) under SDN architecture. IPv6 architecture for Cloud to Vehicle downstream services.

IMT Activities on: Content Centric Networking



Off-path caching

- **Management policies and dimensioning rules** (memory size and placement) in HetNets and D2D devices, to improve both the backhaul traffic and the QoS/QoE of the served user. Cost optimization of edge offloading schemes. Study of the trade-off bw user satisfaction and operator cost. **Off-path** caching.
- New architectures leveraging better resource (CPU) virtualization and management. New protocols (MPTCP) for smoother and robuster communication.

IMT Activities on: Quality of Experience

- Analysis and design of **adaptive video streaming algorithms** and opportunistic scheduling algorithms. A QoE aware directional beam scheduling for scalable video coding (SVC) streaming.
- Study of the QoE (interruption frequency and duration, video frame loss probability) of **live mobile TV** users in the presence of a playout buffer at the receiver side.
- Cross-layer, **multi-RAT mechanisms** for enhancing video delivery, e.g. a cooperative retransmission mechanism for broadcast data flows via cellular network to improve QoS.

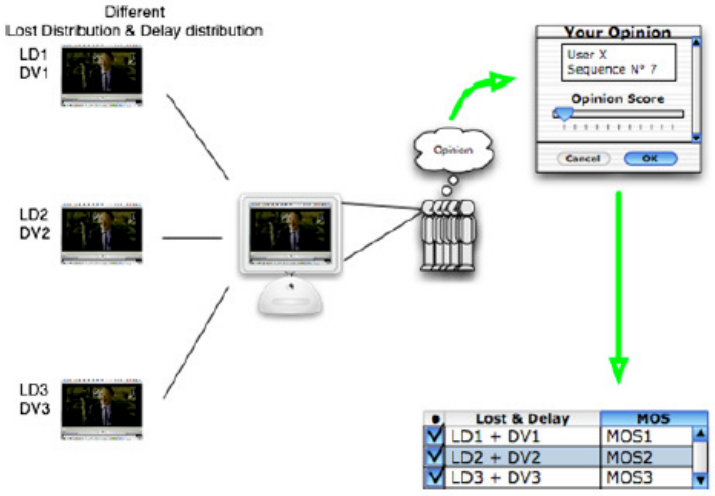
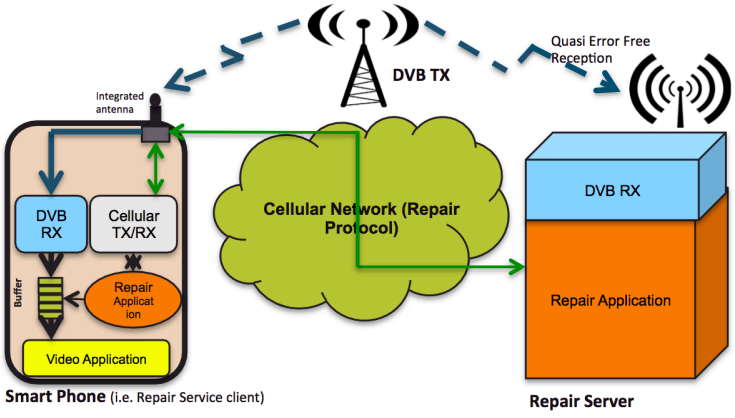
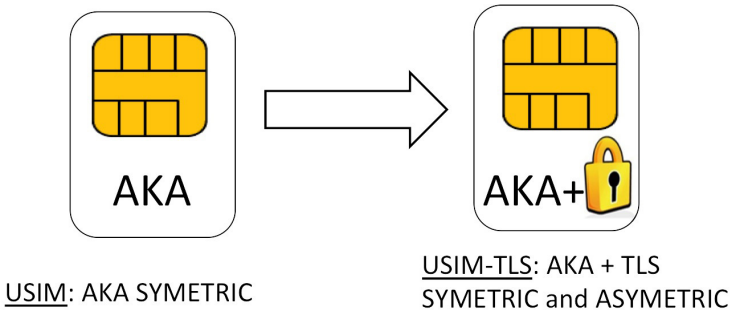


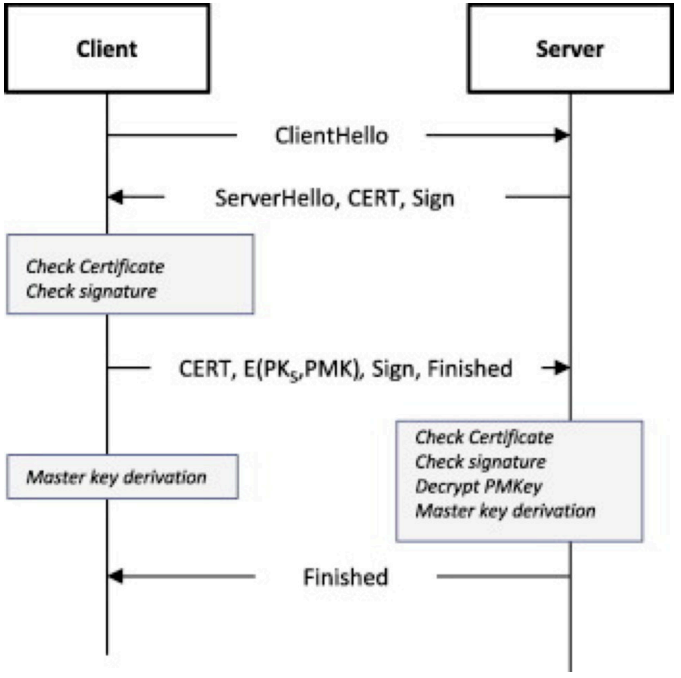
Fig. 1. Subjective Quality Assessment Phase



IMT Activities on: Security and Privacy

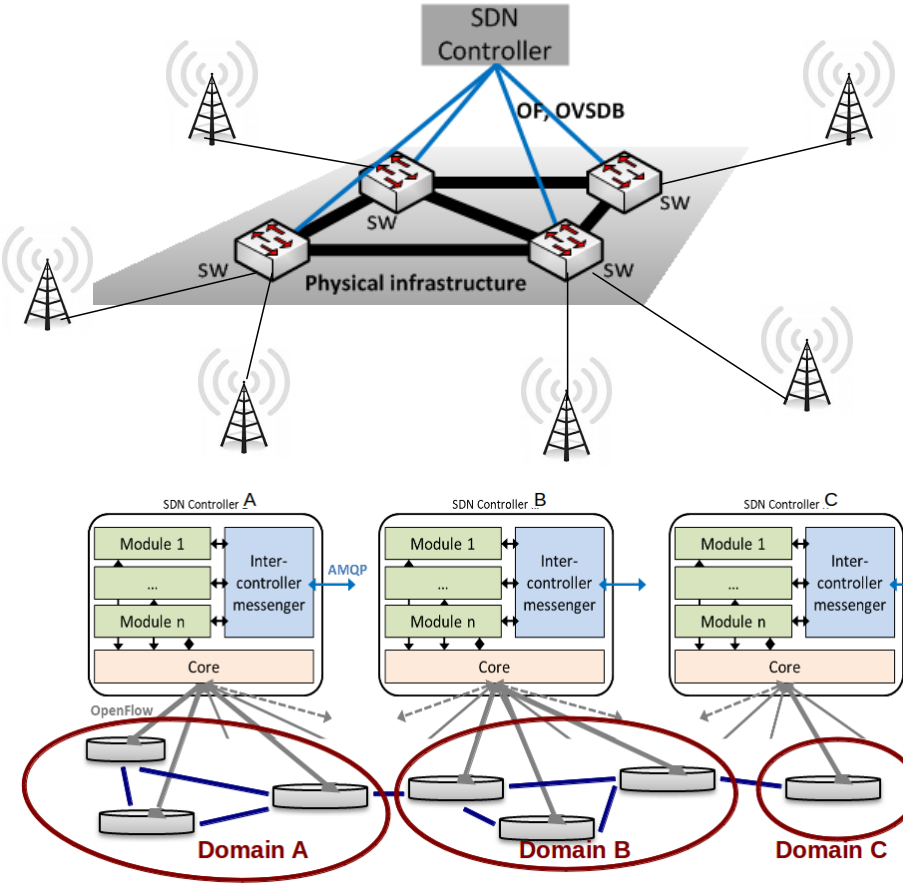
- **Physical layer** security. Secret key generation from channel randomness.
- **A new USIM-TLS generation** implementing AKA and supporting TLS in order to ease SLA-type of mechanisms
- **Privacy and security in ITS**: development of a **PKI for ITS**, **topology of Certification Authorities**, development of a **detection system** to filter out malicious vehicles.
- Lightweight collaborative key establishment scheme for the **Internet of Things**.
- Privacy in **mobile crowdsourcing** using mobile cloud computing.



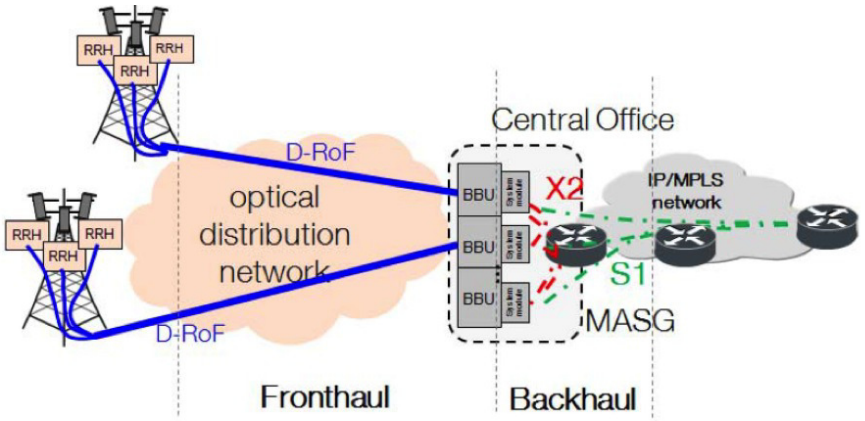


IMT Activities on: Software Defined Networks

- **Architectures** (distribution of functions across controllers, # and placements of controllers), **protocols and algorithms** (failure detection, fail-over and recovery techniques, fast convergence and loop avoidance) for resiliency and stability of the control plane.
- **Network store**: an SDN based market place gathering 5G applications and network functions run on cloud infrastructures for operators, companies and OTTs.
- Cellular network management based on **Big Data** stream processing.



IMT Activities on: Cloud Architectures

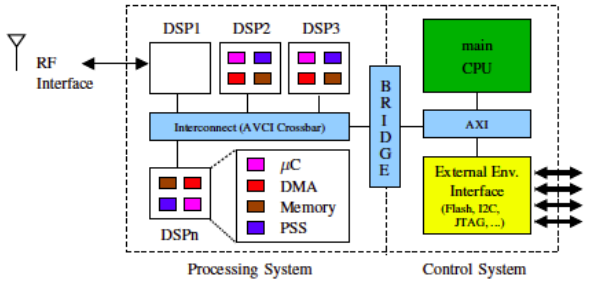


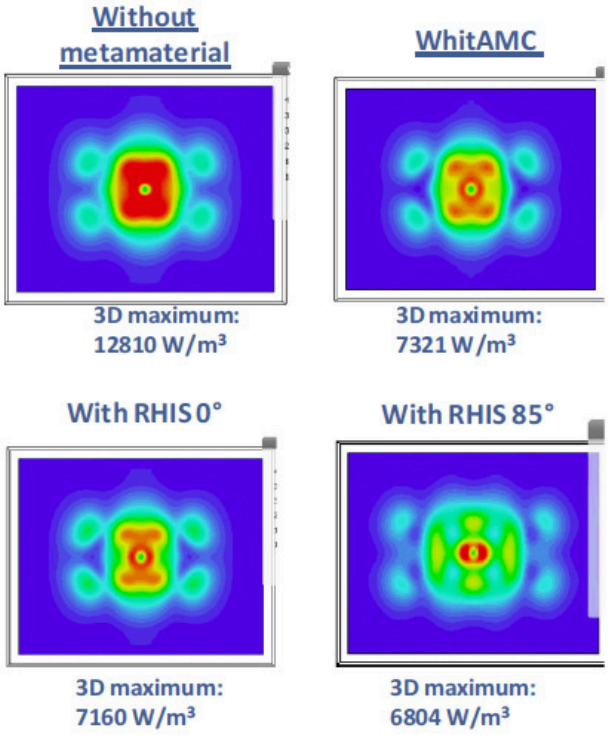
Source: P. Chanclou et al., « Optical Fiber Solution for Mobile Fronthaul to Achieve Cloud Radio Access Network », Future Network & MobileSummit 2013 Conference.

- **Engineering rules** to deploy Digitized Radio-over-Fiber (D-RoF) fronthaul infrastructures able to sustain 5G traffic and save processing resources. BBU processing load models for C-RAN. Virtualized clouds architecture for BBU processing.
- Mobile Cloud **architectures**. **Mobile Cloud Computing strategies** to provide context-aware advanced services to the mobile users. Mobile Cloud offloading strategies to alleviate some tasks from device to cloud. Management of radio, computing and storage resources in Cloud Mobile Gaming.

IMT Activities on: RF Design

- **RF transceivers** for 5G BS and MS applications, including Direct digitization RF receivers based on delta-sigma modulation & ADC architectures with signal conditioning (DPD) and digital post-correction; digital architectures for **software defined radio** design
- Design of **RF front-ends** implementing **band aggregation**, characterization and modeling of amplifier non linearities in **mmW** bands, design of **reconfigurable multiband antennas**.
- **Modeling of the radio channel** (incl. terminal part) using joint antenna-propagation statistical models.





IMT Researchers Working on 5G

Eurecom: C. Bonnet, L. Cottatellucci, P. Elia, D. Gesbert, J. Haerri, F. Kaltenberger, R. Knopp, N. Nikaein, T. Spyropoulos.

Telecom Bretagne: C. Abdelnour, J.-M. Bonnin, B. Cama, C. Douillard, F. Guilloud, G. Habault, X. Lagrange, G. Le Gall, L. Nuaymi, G. Simon.

Telecom Lille: L. Clavier, A. Meddahi.

Telecom SudParis: H. Afifi, T. Chahed, H. Chaouchi, N. Crespi, V. Gauthier, B. Jouaber, D. Zeghlache, D. Zhang.

Telecom ParisTech (COMELEC): L. Apvrille, X. Begaud, J.-C. Belfiore, E. Bergeault, P. Ciblat, J.-C. Cousin, P. Desgrey, C. Jabbour, W. Hachem, A.-C. Lepage, V.-T. Nguyen, R. Pacalet, H. Petit, G. Rekaya, C. Roblin, A. Sibille, A. Tchamkerten, M. Wigger.

Telecom ParisTech (INFRES): T. Bonald, N. Boukhatem, C. Chaudet, M. Coupechoux, L. Decreusefond, M. Gagnaire, A. Giovanidis, P. Godlewski, L. Iannone, R. Khatoun, H. Labiod, P. Martins, G. Memmi, D. Rossi, J.L. Rougier, A. Serhrouchni, P. Urien, A. Vergne.

The End

Thank you for your attention !