EU FP7 Call 8 Project iJOIN
iJOIN: Interworking and JOINt Design of an Open Access and Backhaul Network Architecture for Small Cells based on Cloud Networks

iJOIN vision towards 2020 radio access technologies

February 2014

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The iJOIN Project

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- Funding scheme: STREP
- Objective 1.1
- Duration: 30 months
- Begin: 01 November 2012

- Industry partners
  1. NEC (UK)
  2. Telecom Italia (IT)
  3. Telefonica (ES)
  4. Sagemcom (FR)
  5. Intel Mobile Communications (FR)
  6. HP Italy Innovation Center (IT)

- Research institutes
  7. IMDEA (ES)
  8. CEA (FR)

- Universities
  9. University of Bremen (DE)
  10. University of Surrey (UK)
  11. University of Dresden (DE)
  12. Universidad III Carlos de Madrid (ES)
Outline

- Motivation and Background
- Key Concepts
  - RAN as a Service
  - Joint RAN and backhaul operation and design
- Results
- Summary
MOTIVATION AND BACKGROUND

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Motivation

- More complex content
- More frequent usage
- Increase of mobile subscribers
- Powerful devices

Demand for 500-1000x data rates

500 – 1000x increase in overall traffic demand …

- Exponential increase of mobile data subscribers (4x 2006-10 in EU)
- Internet content more complex (Avg. website 3x size in 5y, 90% of all www are multi-media)
- Mobile devices are used more frequently (iTunes has 500k apps, adding 10k each day)
- Devices become more powerful (Increase by 100% in 2007-10 of wireless users)

Development of cellular data rates…

- Cellular peak data rate increase every 10y by factor 100
- Services evolve → design today for services of tomorrow
- Digital agenda requires this development

Cellular peak data rates over time
Introduction

Cellular peak data rates over time

Data Rates [kB/s]

100,000
10,000
1,000
100
10
1


GSM
GPRS
EDGE
HSDPA
WIMAX
LTE
LTE-A

Transistor Density

Transistor Count (10^6)

10,000
1,000
100
10
1
0,1


Intel Xeon Phi
Sparc T3
Core i7
Opteron
AMD K8
Pentium Pro
Pentium Pro

Storage Area Density

Storage Density (GBit/in²)

1000
100
10
10
1
0,1


Storage
Processing
Communication

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How the “Cloud” changes the picture …

- C-RAN
- RAN-Sharing
- SDN
- SDR

- NFV
- Soft-EPC
- SDN

- SaaS
- PaaS
- IaaS

- On-demand
- Broad access
- Pooling
- Elasticity
- Measured

Mobile Network

Radio Access NW
Backhaul NW
Core NW

Virtualisation / “Cloudification”

Communication Technology

Information Technology

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KEY CONCEPTS
Key enablers to satisfy data demands

**Small Cells**
- 50% Total cost of ownership (TCO) savings
- Four-fold increase in density until 2014
- Worth about 6.1bln USD until 2014

⇒ Small-cells are *the* option to handle higher rates and to improve energy/cost-efficiency

**Centralised Processing**
- C-RAN handles inter-cell interference, allows for higher utilisation and to avoid peak-provisioning
- Up to 50% energy-saving
- 20%-50% OPEX reduction, 15% CAPEX reduction
- Requires high capacity and low delay backhaul

⇒ Centralisation is an option to implement the network but requires more flexibility than today
Key Concepts

- **Flexible centralisation through RANaaS (RAN-as-a-Service)**
  - Offer RAN functionality as cloud-service
  - Simplified RAN management and flexible small-cell solutions
  - Allow to flexibly shift functions from RAN to cloud
  - Reduce complexity & cost through elastic & flexible function assignment
  - Higher energy-efficiency through computational diversity and higher utilisation

- **Joint design and optimisation of RAN and backhaul**
  - Interworking of access and backhaul network
  - Optimise for flexible centralisation
  - Optimise backhaul for small cells
  - Consider heterogeneous backhaul network (fibre and wireless)
  - Relax backhaul requirements through dynamic provisioning (“on-demand”)

[Diagram showing the relationship between Cloud Platform, Core Network, RANaaS, and various network elements like iTN, eNB, iSC, and small cell network.]
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RAN AS A SERVICE
Key Concepts: RAN as a Service

“Conventional” implementation of LTE

RANaaS

Flexible Functional Split

C-RAN Implementation (BB-pooling)

Centrally executed

Netw. Mgmt.

Adm./Cong. Control

RRM

MAC

PHY

RF

Centrally executed

Example: Partly centralised (inter-cell) RRM

Example: Joint Decoding

Executed at BS

Executed at RRH
Key Concepts: RANaaS Benefits

- Computational diversity
  - Exploitation of temporal and spatial traffic fluctuations
  - Efficiently use available resources, scale resource according to needs (resource pooling, elasticity)
Key Concepts: RANaaS Benefits

- Localized optimisation
  - Optimisation based on purpose, deployment, ...
  - Using software implementation rather than configuration (SON)
  - Flexible software assignment over time and space

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JOINT RAN AND BACKHAUL OPERATION AND DESIGN
Key Concepts: Joint RAN/BH Operation

Logical Architecture

Physical Architecture

Joint Operation and Optimization

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Key Concepts: RAN-BH Interworking

- SotA:
  - Separate optimisation/operation of RAN and backhaul
  - No standardised interfaces for RAN-Backhaul interaction
- But: Immediate impact of backhaul on RAN performance

- Example: Mobility
  - Increased HO rate in dense networks
  - High backhaul latency → higher probability for RLF
  - Solutions:
    - Opportunistic handover
    - Multi-connectivity
    - Target-cell initiated HO
Key Concepts: RAN-BH Interworking

- **RANaaS**
  - Flexibly adopt degree of centralisation
  - Apply software based on RAN/BH network information

- **Backhaul**
  - Differently prioritise user and control plane traffic from RAN
  - Adapt backhaul network based on load changes in RAN

- **RAN**
  - Optimise RAN load balancing based on backhaul information
  - Provide feedback for backhaul route setup

- **Challenges**
  - Avoiding oscillation
  - Defined standard interfaces (3GPP RAN3/5)
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RESULTS
Main Objectives: Quantitative Measures

**Main Objectives:**

- **Energy-efficiency:** J/bit < 5%
- **Cost-efficiency:** €/bit < 10%
- **Utilisation efficiency:** U > 75%
- **Area throughput efficiency:** R = 100x

**Demand increases by 1000x →**
Area throughput efficiency must increase 100x

**Combat over-provisioning →**
Increased utilization to 75+% 

**Energy demand must remain almost constant → Energy-consumption per bit 1%-5%**

**Revenue per user remains constant but data per user 50-100x → Cost-per-bit 1%-5%**

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Results: Logical Architecture
Results: Common Scenarios (CS)

- iJOIN Common Scenarios (CS):
  - Outdoor focus:
    - CS1: Dense Hotspot in a Stadium
    - CS2: Dense Hotspot in a Square
    - CS3: Wide-Area continuous coverage
  - Indoor focus:
    - CS4: Dense Hotspot in an Airport / Shopping Mall

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Results: Physical Architecture

CS1: Dense Hotspot in a Stadium

CS2: Dense Hotspot in a Square

CS3: Wide-area continuous coverage

CS4: Dense Hotspot in an Airport/Shopping Mall

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SUMMARY
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New paradigms in mobile networks
- Ultra dense heterogeneous networks
- Cloud computing applied to radio access and core network
- Programmable networks, e.g. application of Software Defined Networking to mobile networks
- System-optimization in focus

New opportunities
- Deployment of commodity hardware for RAN processing
- Mobile communication apps
- Dedicated purpose deployments and configurations
Thank you for your attention!