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Tendencies and Challenges in Signal Processing, Modeling and Telecommunications

INTRODUCTION

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Tendencies and Challenges in Signal Processing, Modeling and Telecommunications

Moderators:
Michel Diaz, LAAS-CNRS - Toulouse, France
Eugen Borcoci, University Politehnica of Bucharest, Romania

Panelists:
Andrei Alexandru Enescu, University Politehnica of Bucharest, Romania
António Nogueira, University of Aveiro, Portugal
Elena Troubitsyna, Abo Akademi University, Finland
Michel Diaz, LAAS-CNRS - Toulouse, France
Eugen Borcoci, University Politehnica of Bucharest, Romania
Panel topics

- Short presentations:
  - Andrei Alexandru Enescu: **MIMO systems, their impact on digital communication systems and issues regarding complexity of implementation.**
  - António Nogueira: **Traffic and network modeling**
  - Elena Troubitsyna: **Model-driven development of fault tolerant communication systems**
  - Michel Diaz: **Overlays, Intelligent ad-hoc networks, Embedded networked systems**
  - Eugen Borcoci: **Telecommunication and Future Internet Convergence Challenges**

- Q/As
Tendencies and Challenges in Signal Processing, Modeling and Telecommunications

Michel Diaz
NexComm Panel
Athens June 2010
Main Open Questions

• High level network Overlays

• New intelligent ad-hoc networks

• Embedded Networked Systems
High level network Overlays

• **Overlays**
  – Do not follow the provider (physical) routing
  – Build a virtual new (higher level) layer
  – Include reliability, user optimisation, etc

• **Next generation of set-up up boxes**
  – Very efficient
  – Shared by the provider and the user
  – Will be the next internet P2P equipment
  – What size and what functions can it provide?
New intelligent ad-hoc networks

• Present ad-hoc networks are not related to applications
  – As much as possible Independent
  – Improvements from Bottom-Up cross-layering
  – New intelligent actors (e.g. robots) appear

• Can we drive protocols by applications
  – Excellent Correlation
  – Optimisation and Adaptation
  – Can we add Cognition to the protocols
  – Top Down cross-layering added to Bottom-Up
Embedded Networked Systems - Step 1
Reliable communication systems

- **Formal Description techniques** (Petri nets, Algebraic Calculus, Estelle, LOTOS, SDL,...) for ISDN networking
  - FDTs went to Embedded Systems that increase in complexity
- **To come back to Networking needs**
  - Abstract Models for wireless comm & protocols
  - Models for network Architectures (for layers)
  - Models for (part of) the QoS internet
Embedded Networked Systems - Step 2
New generation of ENS

1. Define a Next generation of mobile and dynamic Embedded Systems based on Ad-hoc networks

2. Handle Complexity of Ad-hoc networks
   – Define the Certification properties needed for Embedded Systems
   – Develop Specification & Verification of Time constraints and Reliability
   – Develop Code generation and certification (certifying the code, the compiler, etc)
CHALLENGES IN 4G COMMUNICATION SYSTEMS FEATURING MIMO SYSTEMS

Lect. Andrei Alexandru Enescu, Ph. D
Politechnic University of Bucharest
CHALLENGES IN SIGNAL PROCESSING

- “MIMO” is the word of the day
- MIMO systems
  - Beamforming
  - Space-time coding
  - Spatial multiplexing
  - Any combination of the techniques above
- Fast decoding algorithms
  - Need for parallelism
- Radio interface... new tendencies?
  - OBSAI / CPRI
- Fast memory access
  - DDR3 / QDR ...?
MIMO TRENDS

Space diversity – increased coverage

Spatial multiplexing – increased throughput

Beamforming – interference mitigation
Spectral efficiency: $N_t \times M$
- $N_t =$ number of transmit antennas
- $M =$ modulation intrinsic spectral efficiency (e.g. 1 b/s/Hz for QPSK $\frac{1}{2}$, 5 b/s/Hz for 64QAM $\frac{5}{6}$)
- Example: MIMO 4x4 + 256 QAM $\frac{7}{8} \Rightarrow 28$ b/s/Hz!
  - 560Mbps @ 20MHz bandwidth
- Some limitations will come from:
  - Training symbols
  - Implementation loss
  - Logical channels

Who will carry all this throughput??
- Fast DSPs
- Fast digital interfaces (radio interfaces)
- Rapid memory access
MIMO ALGORITHMS

- ML algorithms used for decoding have to deal with codewords of $2^M \times N_t$
  - 256QAM with 4x4 => $256^4$ possibilities = $2^{32}$ codewords (~ = 2E+9 search space!!)

- MMSE and ZF algorithms exhibit tremendous implementation loss especially for large $N_t$

- Find hybrid solutions
  - Quasi-ML: Sphere decoders
  - Implementation-oriented algorithms (parallel features)
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Tendencies and Challenges in Signal Processing, Modeling and Telecommunications

Telecommunication and Future Internet Convergence Challenges

Eugen Borcoci,
University Politehnica Bucharest
Telecommunication and Future Internet Convergence Challenges

- FACTS

- Telecommunication and Internet convergence - recognized and developed – last 15 years
  - Full service integration - based on packet networks support and layered architectural stack
    - Intelligent terminals
    - Flexible IP –based transport
- Future Internet – hot topic in discussion
- How to evolve?
  - Evolution
  - Revolution
  - Something in the middle?
- How the Telecom “world” will participate in this initiative?

- Many efforts to define/re-define the future directions of FI (seen from different point of views): Research groups, Academia, Industry, Standardization organizations, Governments, Users, ..
  - Still – there are many open FI issues, including discussion/revision of the basic concepts

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Telecommunication and Future Internet Convergence Challenges

- Telecommunication view
- Next Generation Networks Architecture (ITU-T, ETSI, 3GPP)

NGN

- *packet-based, broadband* network
- provides Telecommunication *multiple services*
- *QoS-enabled* transport technologies
- service-related functions are independent from underlying transport-related technologies.
- *flexible access* for users to networks and to competing service providers and/or services of their choice.
- *generalized mobility* which will allow consistent and ubiquitous provision of services to users.

- Standardization actors: ATIS NGN FG, ITU-T NGN FG, ETSI TISPAN, 3GPP, etc.
Telecommunication and Future Internet Convergence Challenges

- **Telecommunication view**

- **Key requirements satisfied by the NGN Architecture**
  - **Trust and security:**
    - Operator should be able to trust the network.
    - User should be able to trust the operator.
  - **Reliability:** Users should find it reliable.
  - **Availability:** Network should always be available.
  - **Quality:** Able to control and guarantee the Quality of the Services.
  - **Accountability:** Determine usage of the Service.
  - **Legal:** Comply with laws in the local jurisdictions.
  - **Generalized** Mobility and services support.

- **Note:** Classical and current Internet only partially respond in very controllable manner to the above requirements.
Telecommunication and Future Internet Convergence Challenges

- **Telecommunication view**
- NGN example:
- 3GPP release 6, 7, etc.: IP Multimedia Subsystem (IMS)
  - telecomm. network for broadband fixed and mobile access
  - facilitates convergence of networks and services
  - enables different business models across access, core network and service domains
  - Is an IP based network
  - *Session Initiation Protocol (SIP)* and family are used for call & session control
    - enables any IP access to Operator IMS, from Mobile, Home, Enterprise domain
    - enables service mobility
    - enables interworking towards circuit switched networks
    - maintains Service Operator control for IMS signaling & media traffic.
Telecommunication and Future Internet Convergence Challenges

- Telecommunication view

- NGN high level view of the architecture
  - Some questionable features
    - Wall gardened- style (e.g. IMS) (restricted “democracy”??)
    - Do not mix the transport and application
    - Very complex architecture: many GWs,
    - Not enough flexible,
    - …

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Telecommunication and Future Internet Convergence Challenges

- Future Internet
- Current Internet:
- Some Critics:
  - Victim of its own success
  - Ossification (TCP/IP invariants)
  - Too many patches (routing, mobility, security, signalling, ...)
  - Location/Identity unit
  - Neutral character of the network??
  - Low security and trust
  - Not powerful enough management and control
  - ...see key features that NGN pretends to fulfill
Future Internet

Needs/trends to be answered (partial list)

- **Connectivity**
  - Very high rate throughput - E2E, ubiquitous good/cheap network access
  - Universal connectivity of devices, coupling of virtual world data with physical world information (RFID, sensors)
  - Mobility needs (micro, macro, terminal/session, network mobility)

- **Security and trust**
  - Need for much more security, trust, privacy, anonymity capabilities

- **New services aspects:**
  - VoIP, P2P-based, IPTV, 3D, composable services, ..
  - User generated content and services, User controlled infrastructure,
  - Novel human-computer interaction techniques
  - Personalized services will become widespread on the FI.
  - **Service-centric aware, content centric aware**
  - Computing and software as a network-centric service.

- **Management and control**
  - Negotiated management and control of resources, negotiated SLA’s
  - More need for Availability, reliability, and dependability
Future Internet

KEY issues on FI concepts and design:

- **evolution? or clean slate approach? or something in the middle?**
- **Source:** Petri Mahönen, Project Coordinator, EIFFEL, RWTH Aachen University “Evolved Internet Future for European Leadership (EIFFEL)”, FI Conference, Bled, 2008
Future Internet

- The network revolution
  - Software Services
  - Spectrum flexibility
  - Internet of Things
  - 3D Internet
  - Future Multi-Service Networks
  - Converged Packet Networks
  - User created content
  - Net neutrality
  - IPv6
  - NGA
  - Spectrum

Existing Technology

Emerging Technology

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Telecommunication and Future Internet Convergence Challenges

- **FI Initiatives:**
  - **Europe**
    - Networked European Software and Services Initiative
    - FIRE (Future Internet Research and Experimentation)
    - FP&, … research programs
    - Management and Service-aware Networking Architectures (MANA) for Future Internet
    - Forum of Member States, the "Future Internet Forum“
    - *National level initiatives* and programs oriented for FI (partial list): Belgium, France, Finland, Germany, Italy, Nederland, Spain, Sweden, UK, etc
  - …
  - **USA** - GENI/FIND - of the NSF (originated ~10 years ago)
    - GENI - Global Environment for Network Innovation
  - **Japan**: "New Generation Network" initiative (NWGN) complemented with the creation of the NWGN promotion forum

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Future Internet Initiatives (cont’d)

- Example of a FI-oriented project:
  - ALICANTE, 2010-2013, Integrated Project (IP): MediA Ecosystem
  - Deployment Through Ubiquitous Content-Aware Network Environments

- Applying new challenging concepts (Future Internet – oriented) of:
  - Content Aware Networking
  - Network Aware Application

- Proposal of a novel virtual Content-Aware Network (CAN) layer
  - as a part of a full layered architecture
  - focused, but not limited to, on multimedia distribution with Quality of Services (QoS) assurance

- The system supports on a flexible cooperation between
  - providers,
  - operators and end-users,
  - enabling users to access the offered multimedia services in various contexts and also to become private content providers.
Future Internet Initiatives (cont’d)

- **ALICANTE project:**
  - Architectural high level view
Thank you