

Just det att kiale  
får marken själ  
dingarna med sitt  
den paltbröden  
Det finns en lada  
Och det finns m  
som blanda riefat  
u mösorn

ECKEN  
ENINU  
OBJET

MÖBELDESIGN

words  
SQUIS AHAT DÉCAT!!  
Por jaginte p

godford's daughter

BY \* K N P <  
P \* P N Auez - uous  
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männi ska ej  
fiter vad hon  
er vad hon

- Rätt teori och r  
- Allmän rätt  
- Offentlig rätt  
- Aralarätt, skola

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LINKÖPINGS UNIVERSITET

**Erik G. Larsson**  
professor, FIEEE



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# Team and Expertise

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- Doc. Danyo Danev
- Doc. Jerzy Dabrowski
- Doc. Emil Björnson
- Dr. Mikael Olofsson
- Dr. Vladimir Savic
- Dr. Salil Kashyap
- Dr. Julia Vinogradova
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Dr. Hien Ngo

Mr. Antonis Pitarokoilis

Mr. Victor Hei Cheng

Mr. Marcus Karlsson

Mr. Christopher Mollen

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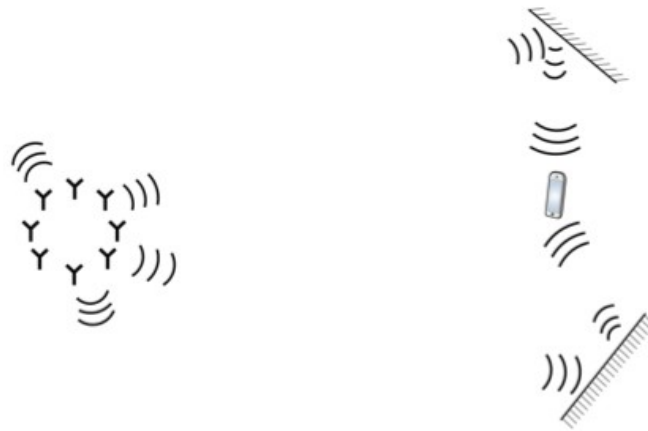
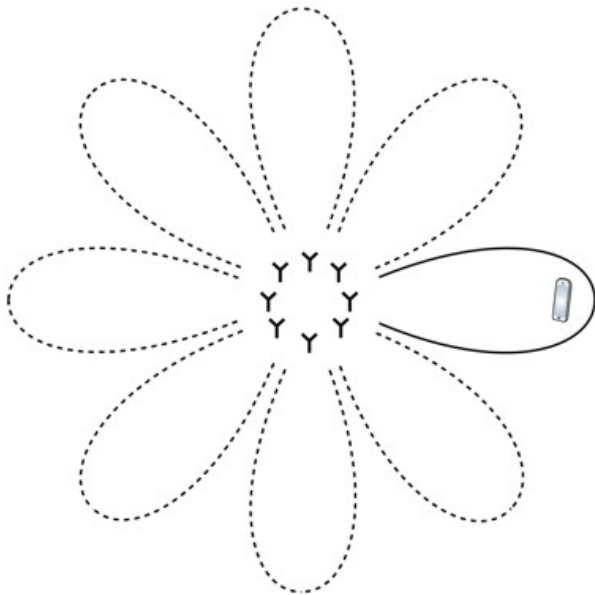
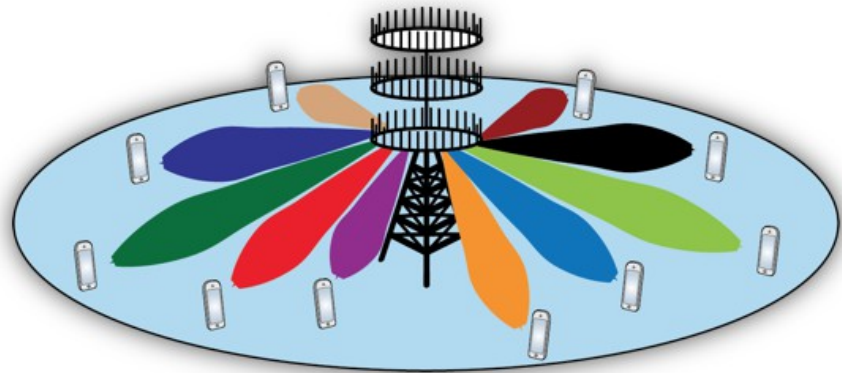
Mr. Trinh van Chien

Statistical signal processing, Inference, Wireless communications, Multiple-antenna systems, IoT, Networks, Optimization, Positioning technology, Digital Electronics



# Massive MIMO for (B)5G

- Key 5G technology
  - ~200 antennas and ~40 users
  - Coherent precoding/detection
  - Highly directed signals
  - Little interference



***Designed to handle non-line-of-sight!***

# Positioning in Tunnels and Mines

- UWB radio technology
- Personnel safety, task optimization, traffic management
  
- Main problems:
  - difficult radio environment
  - irregular architecture



# Robust och Säker Trådlös Kommunikation

- Robusthet mot avsiktlig störsändning
- GPS-spoofing

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Gothenburg riots 2001: chief commander unable to reach any of the 700 officers  
“Military grade” today -> \$1000 off the shelf tomorrow



**SECURITY LINK**  
RESEARCH • EDUCATION • INNOVATION





**BEFORE THE  
DEPARTMENT OF COMMERCE**

In the Matter of )

National Telecommunications and )  
Information Administration )

Development of the Nationwide )  
Interoperable Public Safety Broadband )  
Network )

Docket No. 120928505-2505-01  
RIN 0660-XC002

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**COMMENTS OF WIRELESS @ VIRGINIA TECH**

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**INTRODUCTION AND EXECUTIVE SUMMARY**

The Wireless @ Virginia Tech research group appreciates the opportunity to respond to the National Telecommunications and Information Administration (NTIA) request for comments on the Development of the Nationwide Interoperable Public Safety Broadband Network. This comment is regarding the vulnerability of LTE to intentional and sophisticated jamming attacks.

# FP7-MAMMOET (2014-2016)

## Massive MIMO for Efficient Transmission

 MAMMOET member states

### Austria

- Technikon Forschungs- und Planungsgesellschaft mbH (TEC)
- Infineon Technologies Austria AG (IFAT)

### Belgium

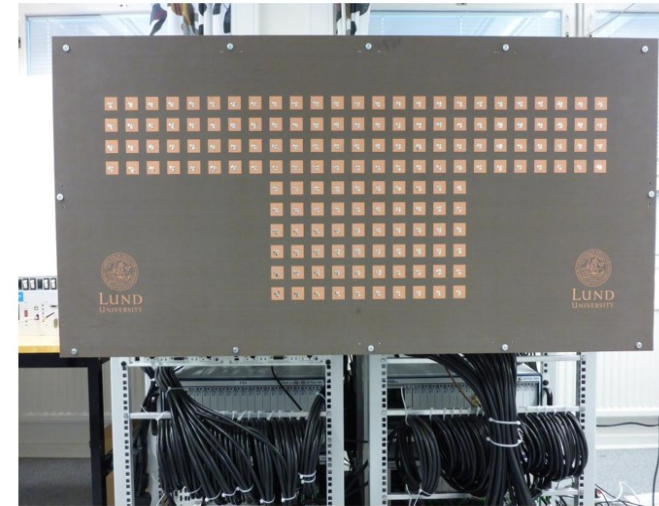
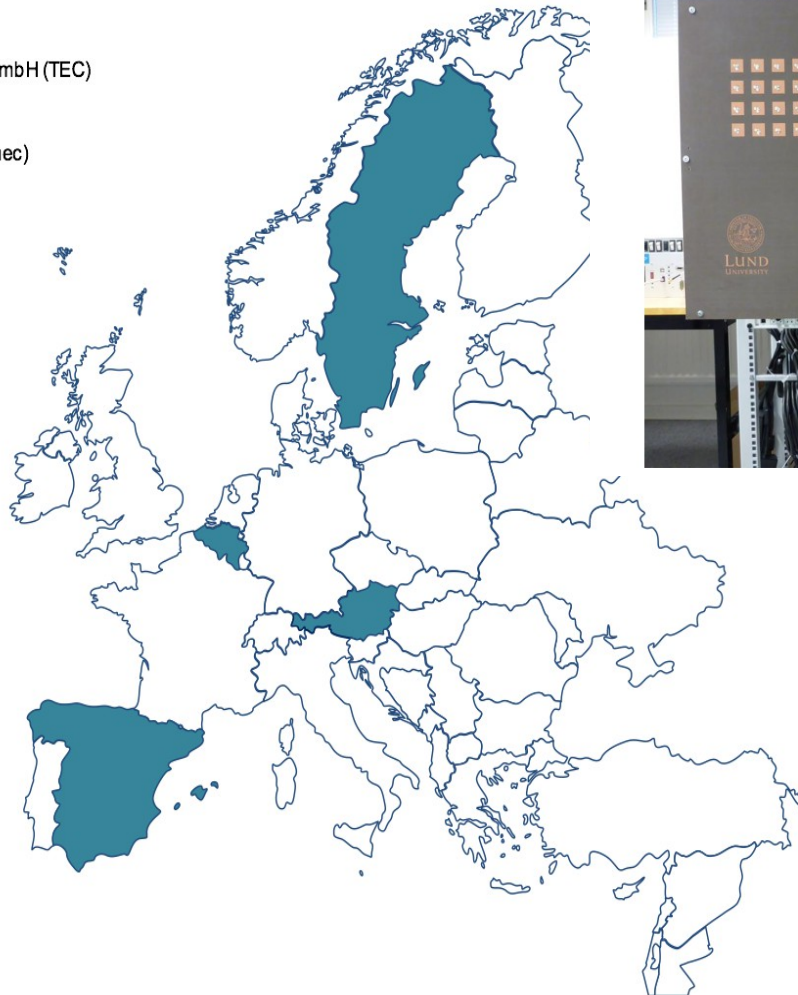
- Interuniversitair Microelectronica Centrum VZW (imec)
- Katholieke Universiteit Leuven (KU Leuven)

### Spain

- Telefonica Investigación y Desarrollo (TID)

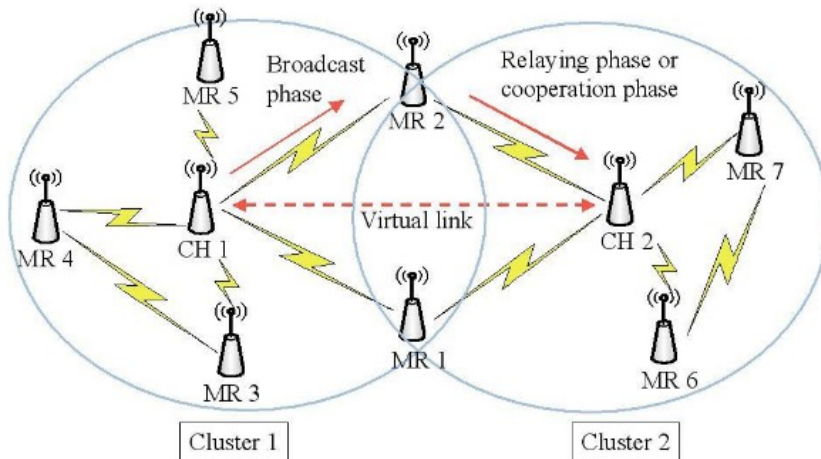
### Sweden

- Ericsson AG (EAB)
- Lunds Universitet (ULUND)
- Linköpings Universitet (LIU)



Massive-MIMO antenna  
Photo: Lund university

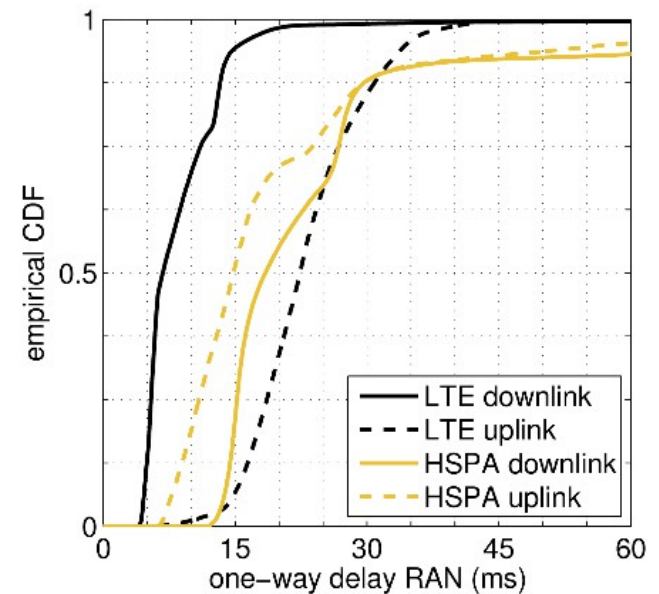
# FP7 – LOLA : Low-latency communications in LTE



 Radio link

- Routing with MAC-level forwarding
- Goal: reduction in latency
- Virtual link uses dedicated RNTIs to identify transmissions
- MRs can cooperate in second hop
- Project challenges
  - Handling interference in SFN: spreading, interference cancelling, orthogonalization
  - Alamouti coding for relay cooperation
  - MAC forwarding procedures
- Testbed
- Implementation on OpenAirInterface
- Demo planned for June 2013

- “LOLA mesh” - Rapidly-deployable mesh network based on LTE
- Cluster head (CH) – analogous to eNodeB
- Mesh router (MR) – UE and core network router
- Single-frequency network
- With LTE, RAN latency is ~30 ms from CH to CH
- For voice calls: delays noticeable at 4-5 hops



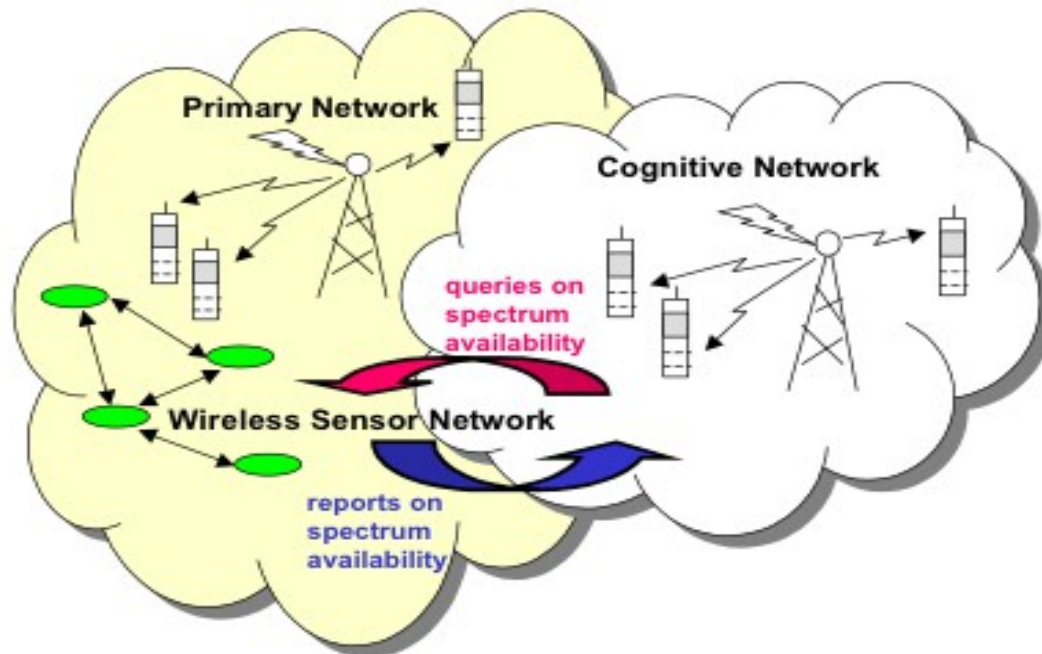


# FP7-SENDORA (2008-2010)

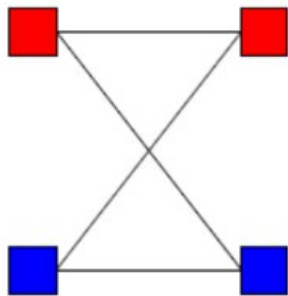
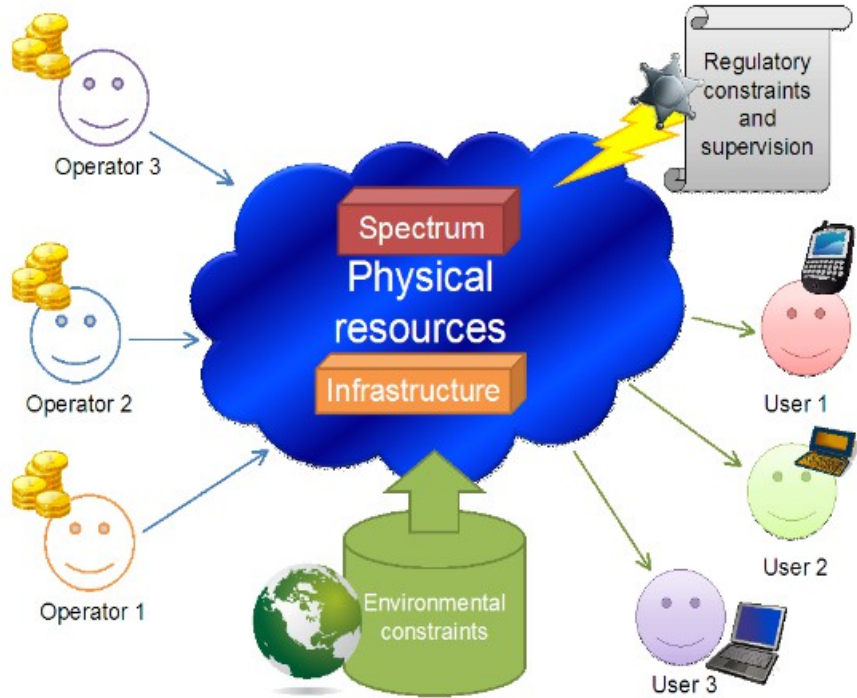
THALES



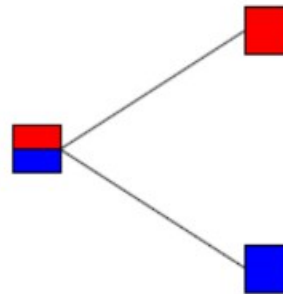
NTNU  
Norwegian University of  
Science and Technology



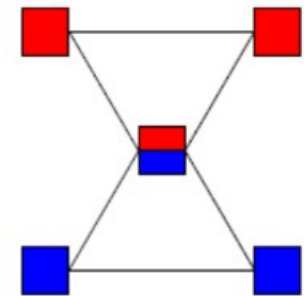
# FP7-SAPHYRE (2010-2012)



Spectrum sharing  
No infrastructure sharing



No spectrum sharing  
Infrastructure sharing



Spectrum sharing  
Infrastructure sharing