Joint Sensing and Communication Design: Applications, State-of-the-Art and the Road Ahead
Would This Become the 6G 'Killer Application'?

Based on Liu, Masouros, Petropoulu, Griffith & Hanzo, TCOM, 2020

Presented by

Lajos Hanzo

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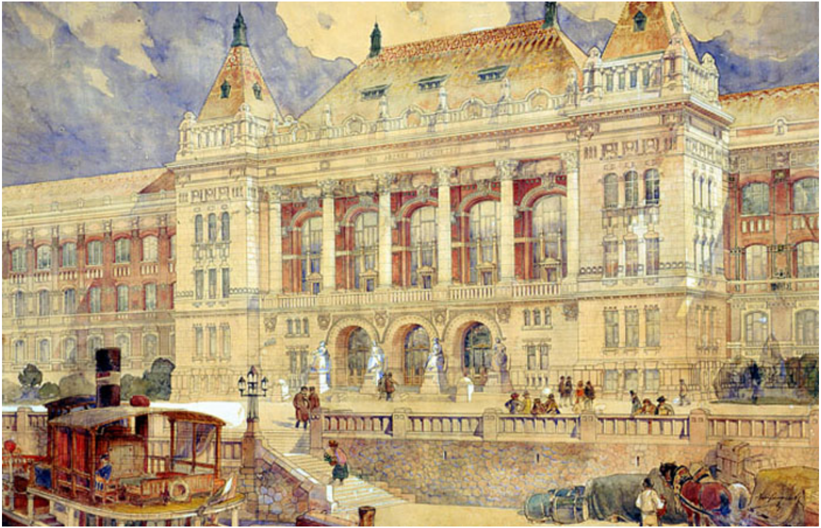
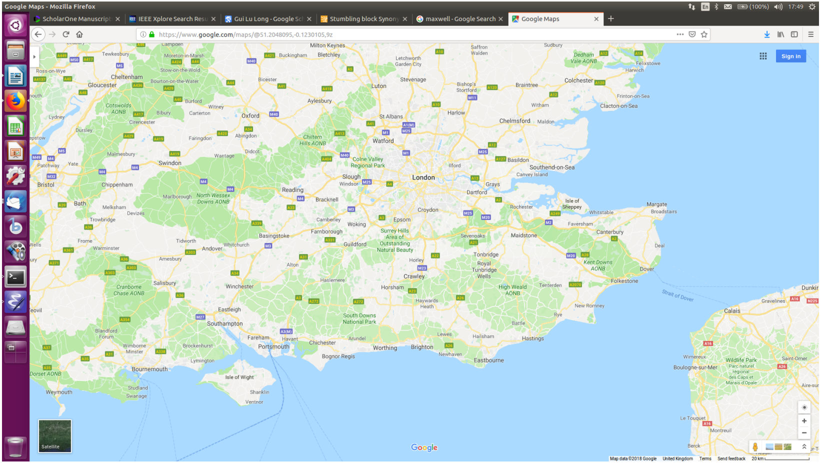
My Alma Mater



The Marconian Legacy...



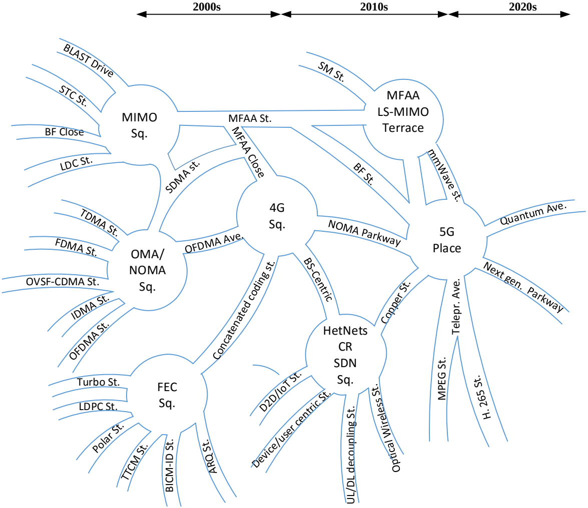
My Current Lab

Wireless Past, Present & Futures...

Overview

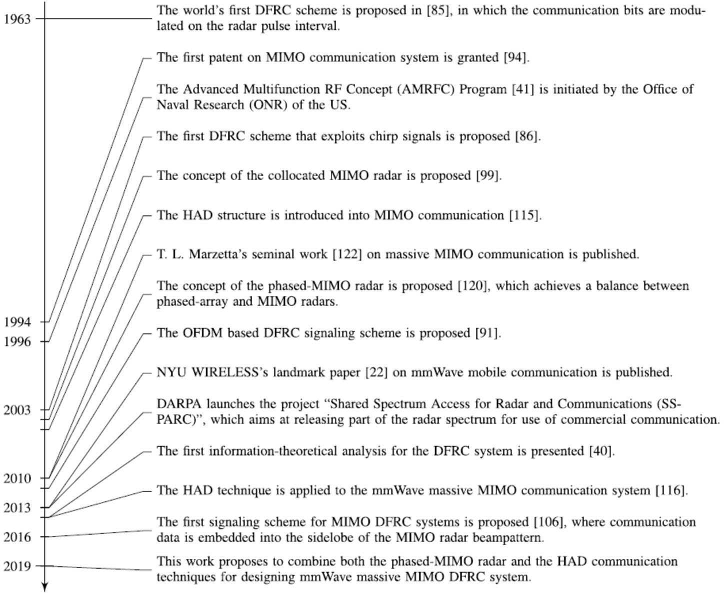
- **Wireless Past, Present & Futures**
- **History & Motivation of RadCom - Hardware Co-design Beyond Spectrum Sharing**
- **What Will 6G Be?**
- **From Conflicting Design Trade-offs to Fully-Fledged Pareto-Optimal RadCom**
- **The Future?**

Wireless History

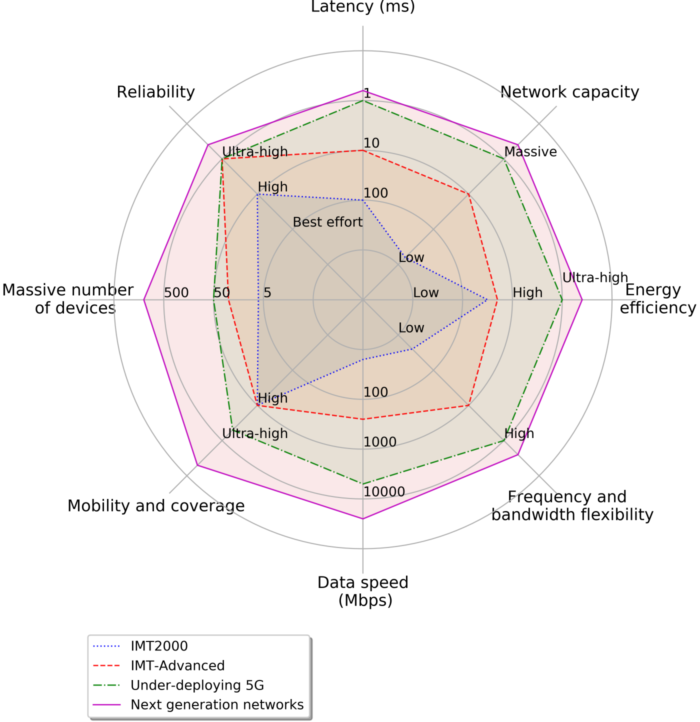


- Liu, Qin, Elkashlan, Ding, Nallanathan & Hanzo: Nonorthogonal Multiple Access for 5G and Beyond, Proceedings of the IEEE, 2017

Dual-Function Radar & Comms (RadCom) History

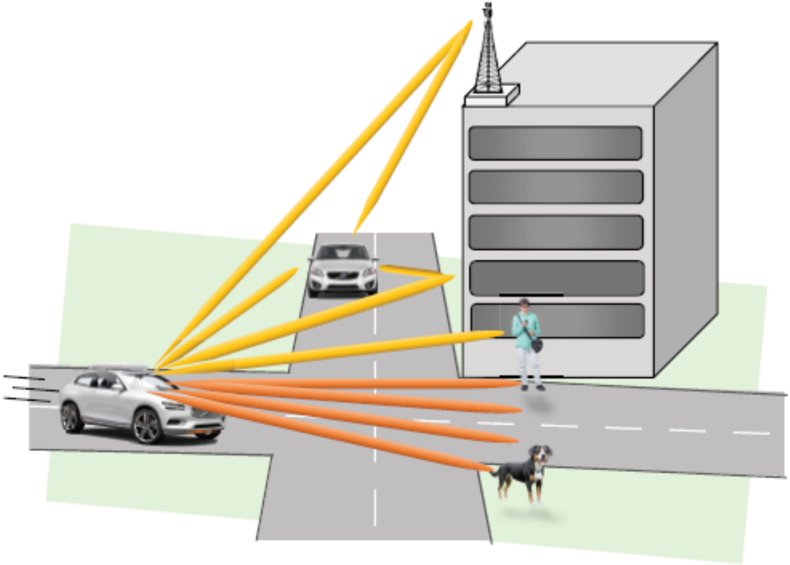


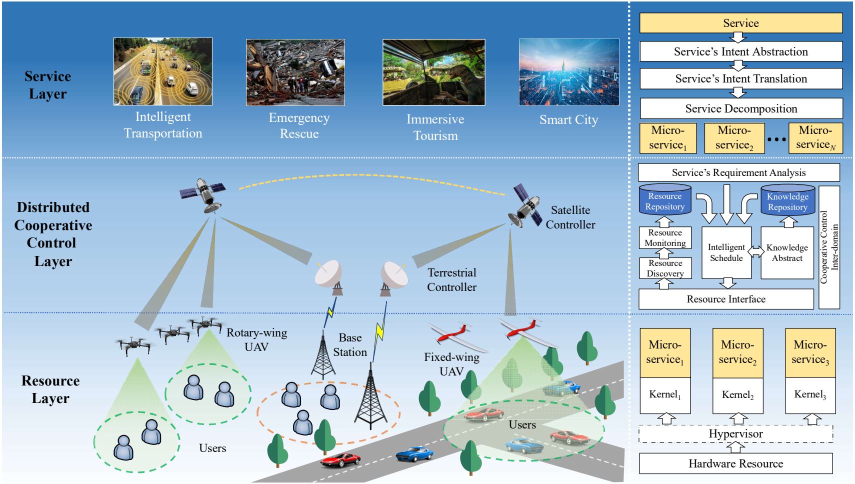
My Thesis: Single-Objective, Single-Function Optimization Is Out, Pareto-Optimization Is In


Latency (ms)
1
10
100
Network capacity
Massive
Low
Energy efficiency
Ultra-high
High
Low
Frequency and bandwidth flexibility
High
Low
Data speed (Mbps)
10000
1000
100
Mobility and coverage
Ultra-high
High
Massive number of devices
500
50
5
Reliability
Ultra-high
High
Best effort
IMT2000
IMT-Advanced
Under-deploying 5G
Next generation networks

Is RadCom Only On About Spectrum Sharing or Hardware Sharing?

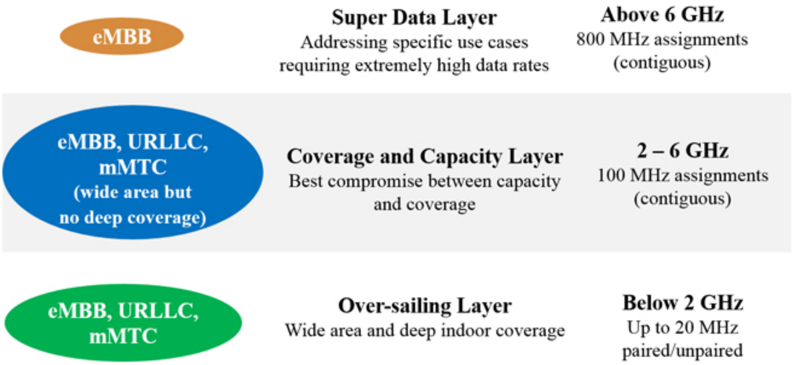
'Killer' Applications...





Service Layer
Intelligent Transportation
Emergency Rescue
Immersive Tourism
Smart City
Distributed Cooperative Control Layer
Satellite Controller
Terrestrial Controller
Resource Layer
Rotary-wing UAV
Base Station
Fixed-wing UAV
Users
Users
Service
Service's Intent Abstraction
Service's Intent Translation
Service Decomposition
Micro-service$_1$
Micro-service$_2$
...
Micro-service$_N$
Service's Requirement Analysis
Resource Repository
Knowledge Repository
Resource Monitoring
Resource Discovery
Intelligent Schedule
Knowledge Abstract
Inter-domain Cooperative Control
Resource Interface
Micro-service$_1$
Kernel$_1$
Micro-service$_2$
Kernel$_2$
Micro-service$_3$
Kernel$_3$
Hypervisor
Hardware Resource

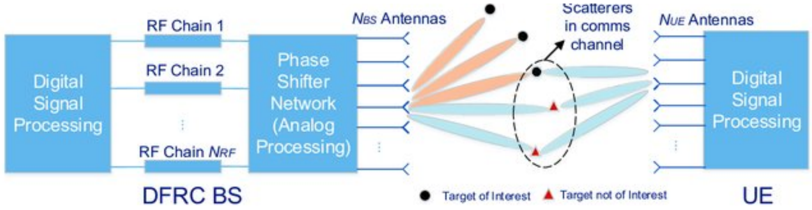
Spectrum Sharing



SOURCE

4G & 5G Spectrum Sharing: Efficient 5G Deployment to Serve Enhanced Mobile Broadband and Internet of Things Applications by Wan, Guo, Wu, Bi, Yuan, Elkashlan & Hanzo, IEEE VTM, 2018

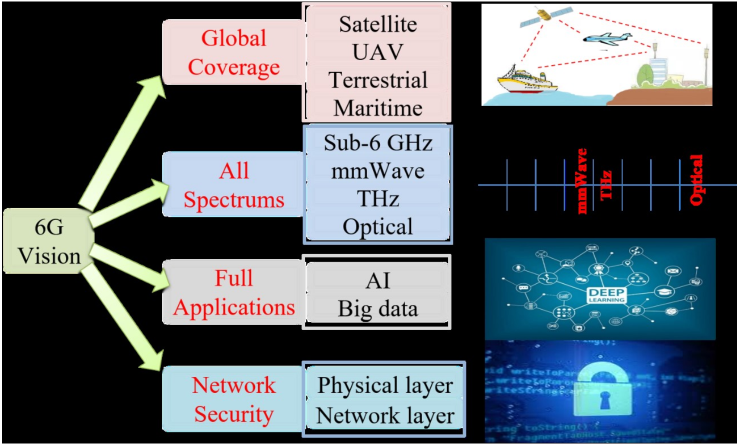
Hardware Sharing:
1/ Joint Waveform Design (PAPR, ACF, CCF);
2/ Synchronization;
3/ **MIMO**;
4/ ML/AI in the Face of Uncertainty



SOURCE

- Joint Radar and Communication Design: Applications, State-of-the-Art, and the Road Ahead, ©IEEE Liu, Masouros, Petropulu, Griffiths & Hanzo IEEE TCOM, 2020
- Mobile Radio Communications by Steele & Hanzo, 1999, Chapter 2, Bello Functions

The Future - What Will 6G Be?



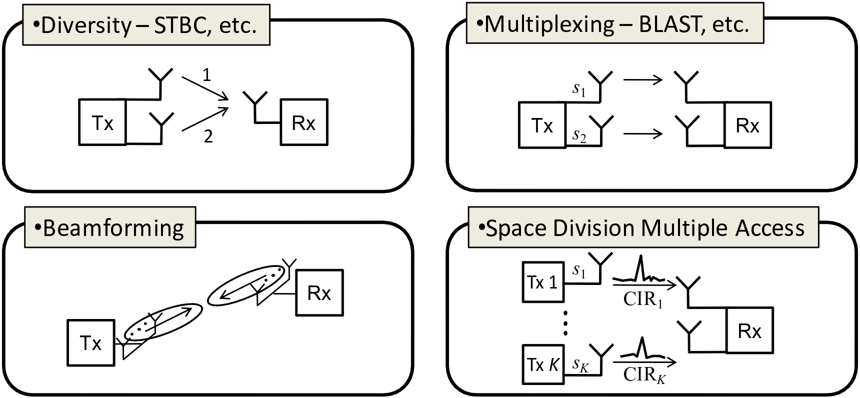
SOURCE

Towards 6G wireless communication networks: Vision, enabling technologies and new paradigm shifts, Science China, 2020 ©You, Wang ... & Hanzo

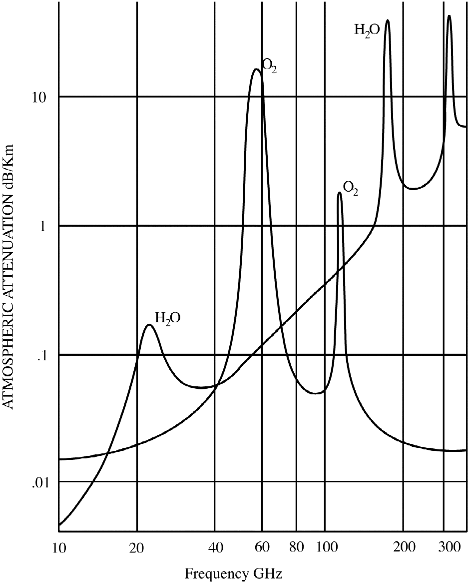
So, Dr Shannon - which MIMO is best for RadCom?

$$C = B \cdot \log(1 + SINR)$$

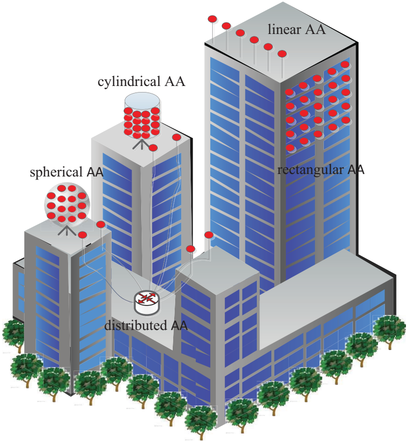
$$C \approx min(M; N)$$



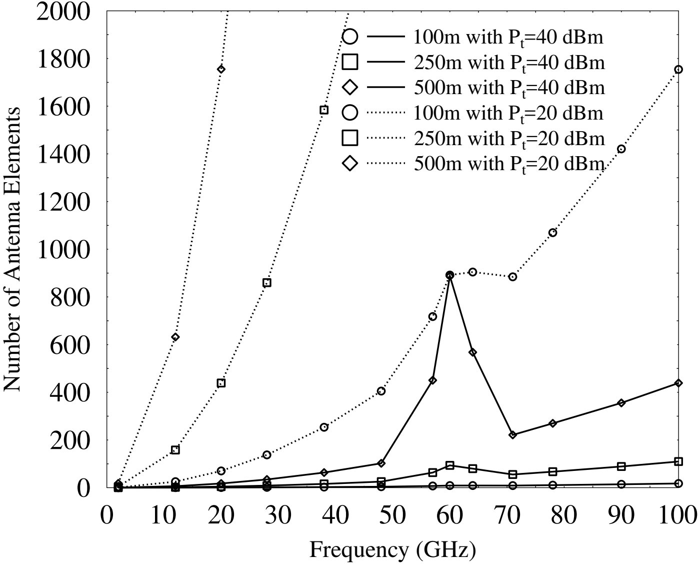
The Pathloss Escalates vs. the Carrier Frequency



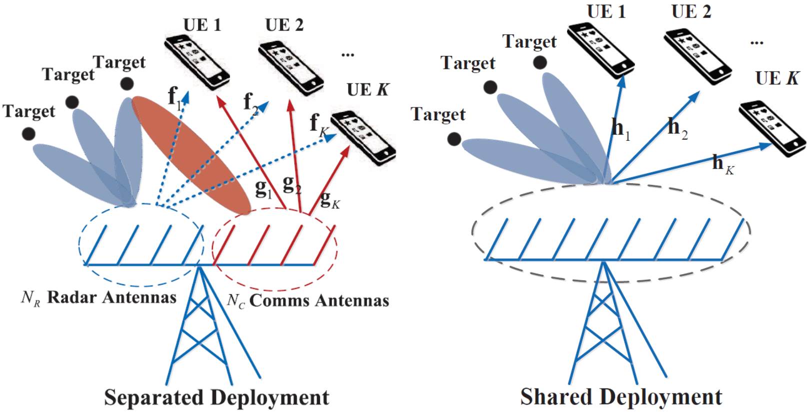
Zheng, Zhao, Mei, Shao, Xiang & Hanzo: Survey of Large-Scale MIMO Systems, IEEE Communications Surveys & Tutorials



No. of Antennas Required for Compensating the Pathloss



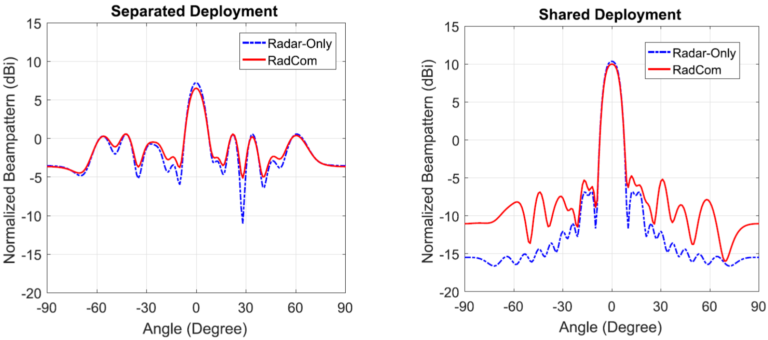
Separate vs. Joint Beamforming



SOURCE

- MU-MIMO Communications With MIMO Radar: From Co-Existence to Joint Transmission Liu, Masouros, Li, Sun & Hanzo IEEE TWC, 2018

Separate vs. Joint Beamforming; SINR=10 dB; K=4; N_R=14; N_C=6; PSLRs are 7 and 15 dB



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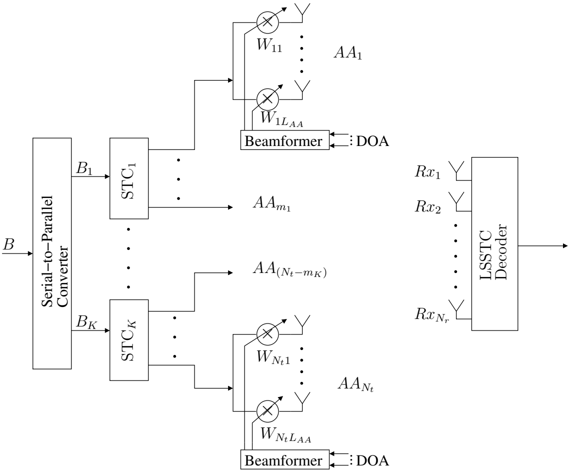
The Future: Pareto-Optimal Multi-Functional MIMOs



SOURCE

- Near-Capacity Wireless Transceivers and Cooperative Communications in the MIMO Era, by Hanzo *et al.* Proc. of the IEEE, 2011

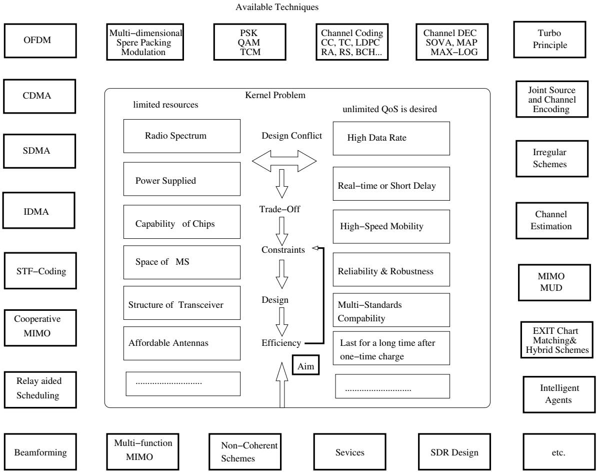
Multi-Component Pareto Optimization: Bandwidth, BER, Delay, Power & Complexity, etc

SOURCE

- Thirty Years of Machine Learning: The Road to Pareto-Optimal Wireless Networks, ©Wang, Jiang, Zhang, Ren, Chen & Hanzo IEEE COMST, 2020
- Joint Radar and Communication Design: Applications, State-of-the-Art, and the Road Ahead, ©IEEE Liu, Masouros, Petropulu, Griffiths & Hanzo IEEE TCOM, 2020

My Thesis: Single-Objective, Single-Function Optimization Is Out, Pareto-Optimization Is In

Pareto-Optimal RadCom Transceiver Design



SOURCE

- Near-Capacity Wireless Transceivers and Cooperative Communications in the MIMO Era, by Hanzo *et al.* Proc. of the IEEE, 2011

Pareto-Optimal RadCom Futures... ©CCBY