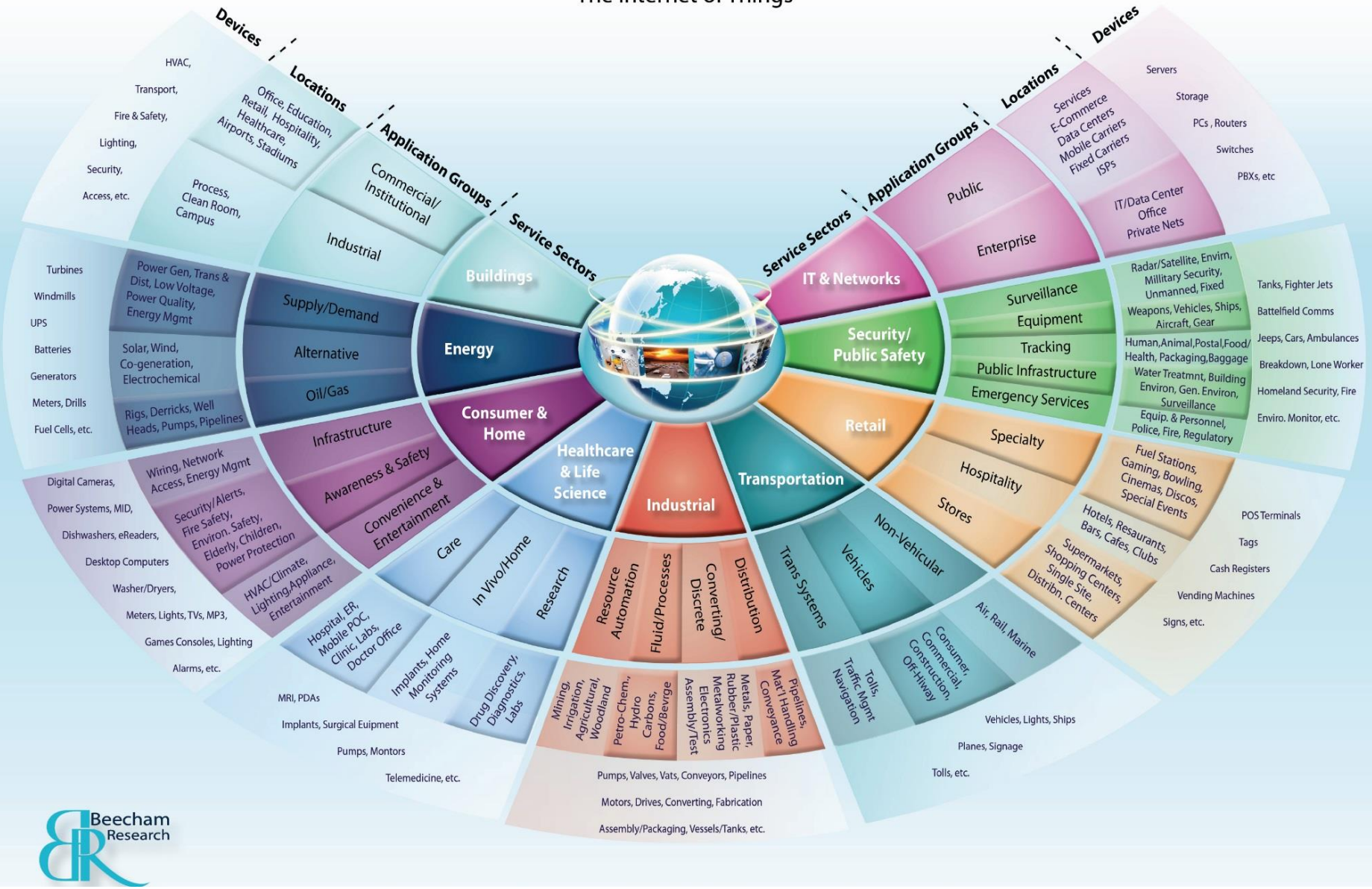
23. Leibniz Conference 2018
Localization Technology for IoT, Telematics and Industry 4.0

November 22-23rd 2018, Lichtenwalde (Germany)

Session: Radio sensor based positioning
Chair: Dr. D. Eggert

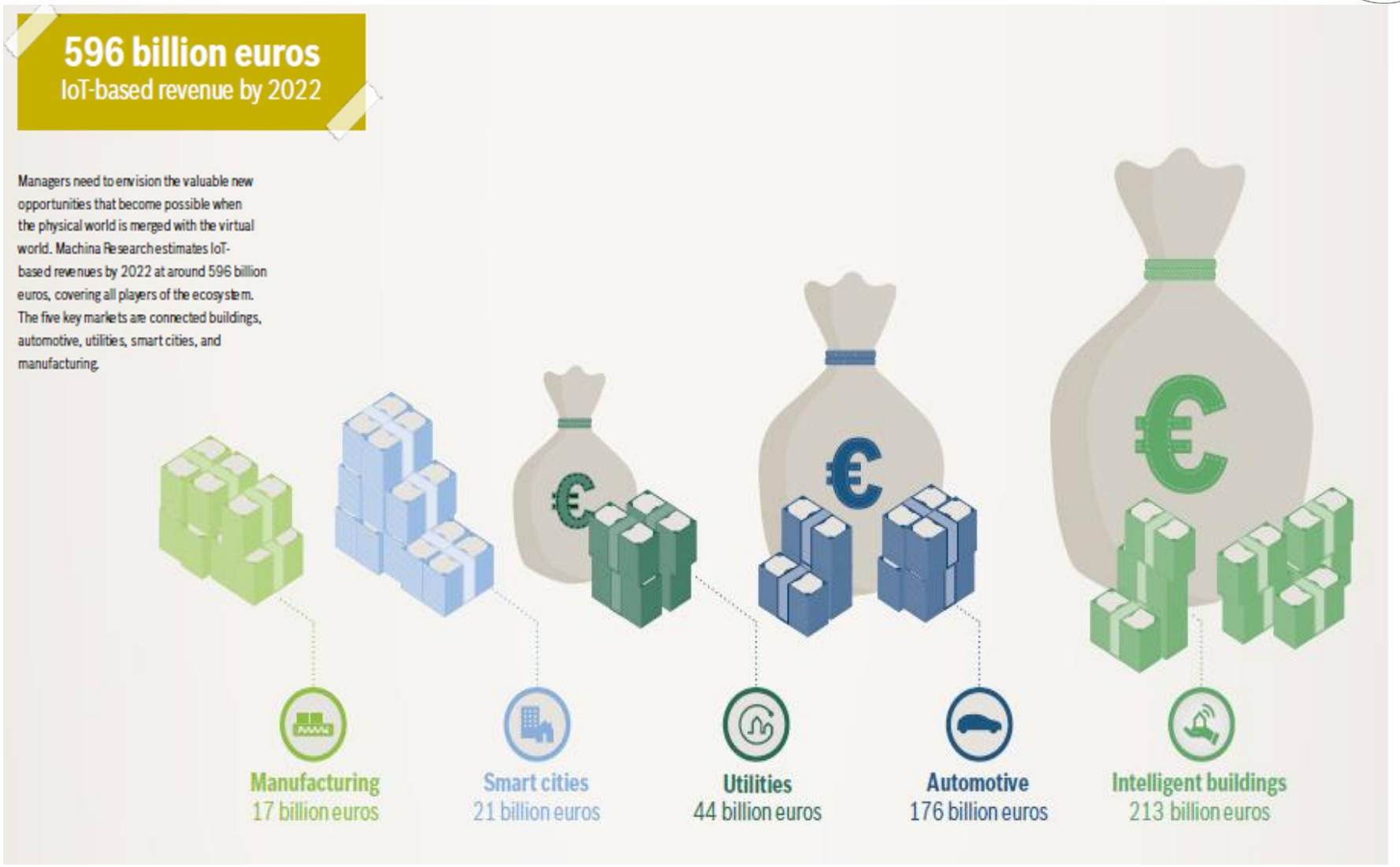
M2M World of Connected Services

The Internet of Things



Beecham Research

IoT – Business Potentials



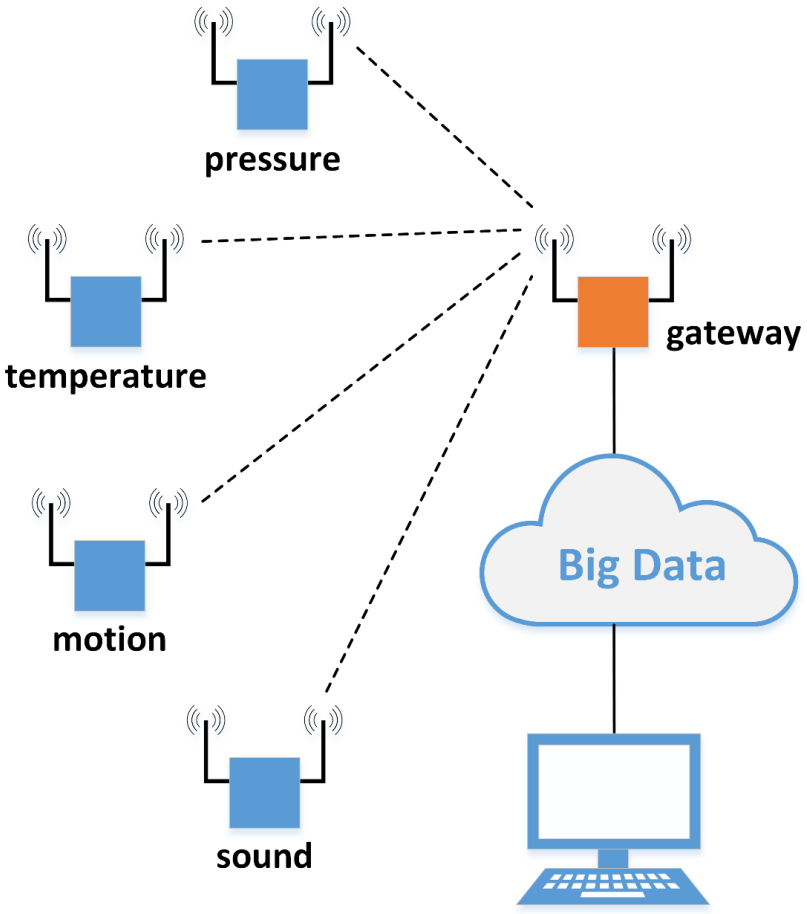
Source: **Capitalizing on the Internet of Things - How to succeed in a connected world,**
http://www.bosch-si.com/lp/iot-white-paper.html?ref=ig-global-2014H1-iot-strategy-whitepaper

Distance Measurement in Wireless Networks

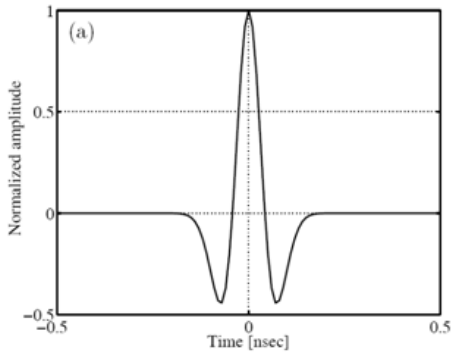
"With 30 billion connected devices and almost 1000 trillion installed sensors in 2020 the question about **where** a measurement has been taken becomes as important as **what** has been measured." (2014)

Wireless Sensor Network:

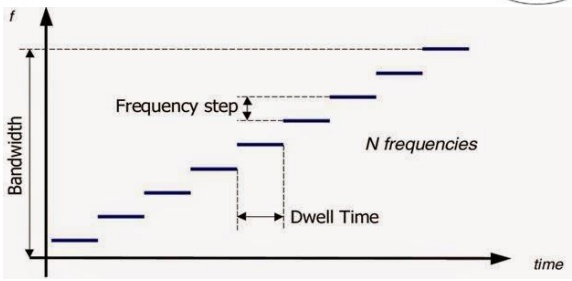
- Distributed autonomous sensors monitor physical and environmental conditions
- Wireless network is used to concentrated sensor data in a central processing unit
- Cloud based data storage enables monitoring and control throughout the world
- Remote access to sensor data through mobile device or terminal



Time Domain vs. Frequency Domain



Measurement Techniques



Ultrawideband Pulse based

Oscilloscope

- Resolution is determined by Pulse Parameters
- Absolute Distance over Time Measure
- TX Power limited by Regulatory Requirements (-41.3dBm/MHz)
- Require High RX and TX BW
- Multi-Node Support by TDoA
- ☺ High Acquisition Speed
- ☹ Low SNR

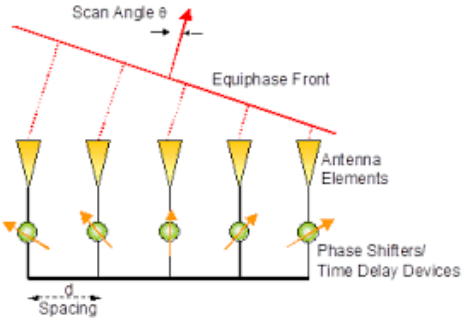
Frequency Modulation

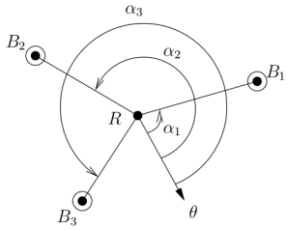
Vector Network Analyzer

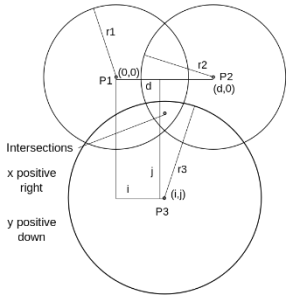
- Resolution is determined by total occupied BW
- Unambiguous Range is determined by Step Frequency
- Rel. high TX Power authorized
- RX & TX BW is relatively small
- Multi-Node: Parallel Measurements in Frequency Domain
- ☹ Lower Acquisition Speed
- ☺ High SNR

- Support Proximity, Position and Tracking
- Low Cost Tag Nodes
- Hybrid Solutions may combine the benefits of the two approaches

From Distance and Angle over Positioning to Tracking







Ad-hoc Distance/AoA Measurement

Intelligent Reference Nodes within a Basic Network

- Proximity/Position(r,α,θ) is computed in Intelligent Reference Nodes directly from radio measurements
- ☺ Enables Faster/Direct Control Response (derived immediately inside reference node)
- ☹ Quality of Position relies on measurements from single reference node

Infrastructure-Based Location Services

Basic Reference Nodes within an Intelligent Network

- Distance (d_1,..,d_n) derived from radio measurements while location is computed at central Server
- ☹ Requires extra transport to central server; application response needs to be propagated through network
- ☺ Higher accuracy by combining measurement data from multiple reference nodes

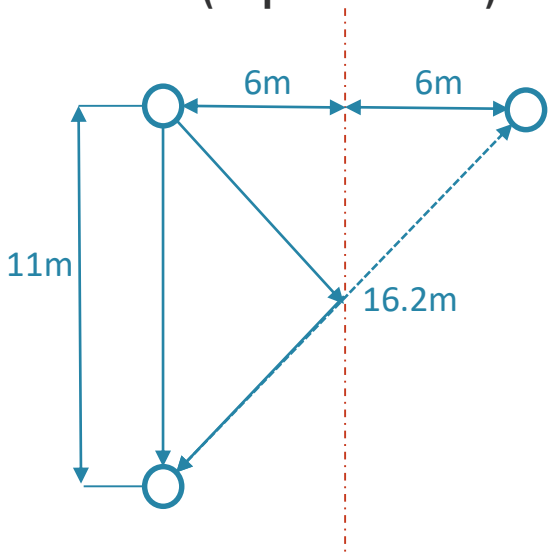
- Support Proximity, Position and Tracking
- Low Cost Tag Nodes
- Hybrid Solutions may combine the benefits of the two approaches

Angle of Arrival

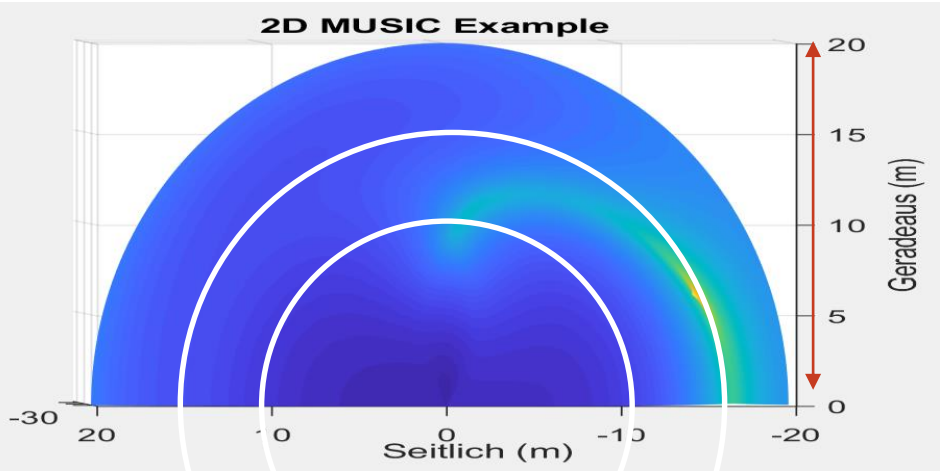
	Synchronized TRX	Time Sequential
Calibration	Online (requ. Calib branch in AFE; shared SPI,… (follow WPAN module design))	None required (Antenna Diversity RF Frontend)
Acquisition Speed	90ms (83 Frequencies)	250ms (83 Frequencies)
Accuracy	< 15 °	<15 °
Outlook	MIMO Approach: Combination of Angle and Distance Measurements	

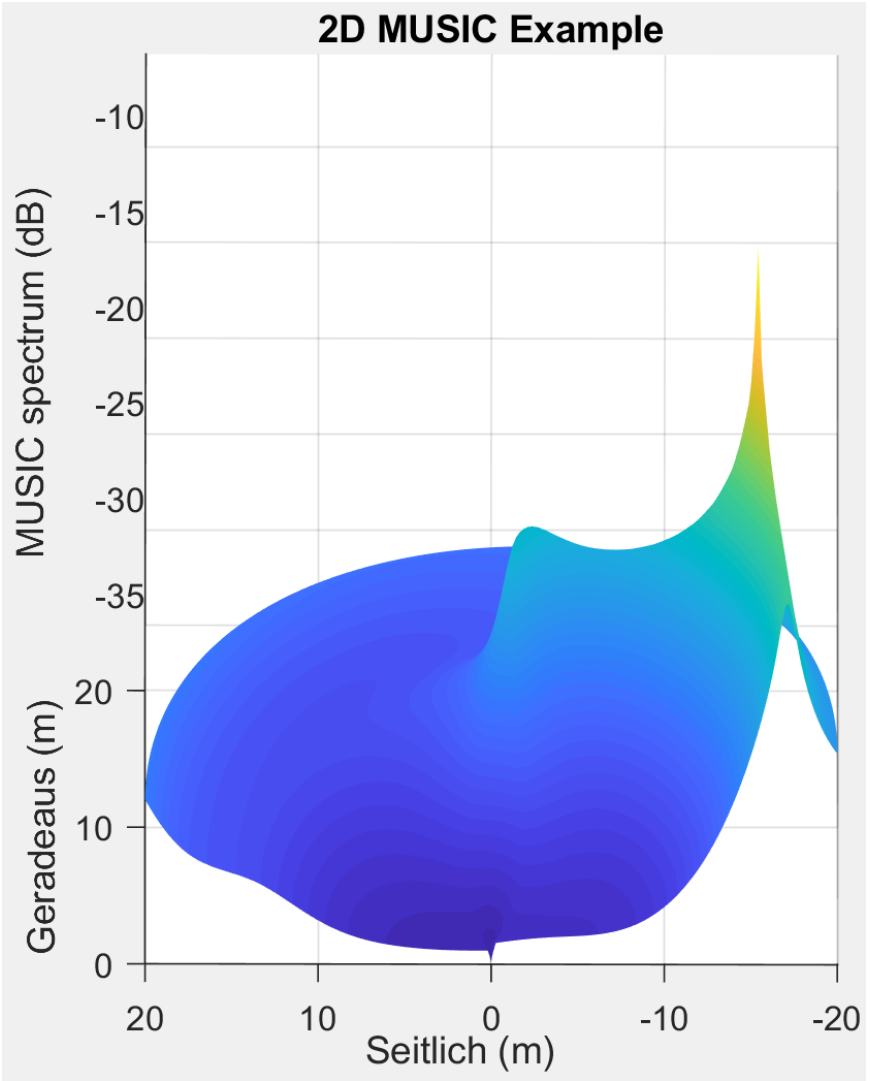
2D – Eigenvalue Analysis: 1x LOS Path 11m + Indirect Path:

Reflection at a wall (Separation 6m)



(incident angle ~45 degree)





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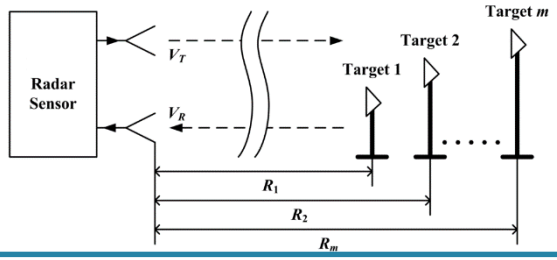
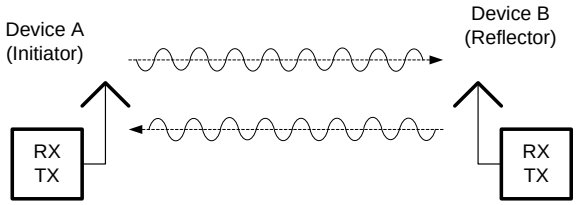
Passive vs Active Reflector



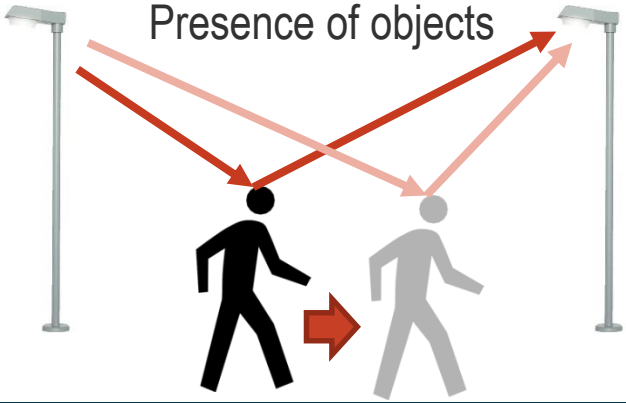


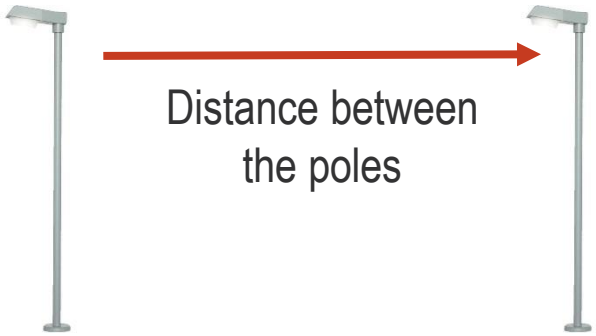
Passive Reflector

- Objects of Interest NOT actively engaged on radio traffic and corresponding measurement process
- Context Recognition as simplest form of radio imaging
- ☺ No extra HW and energy reservoir required for Objects of Interest
- ☹ Evaluation of changes in propagation characteristics primarily the indirect propagation paths; Usually lower SNR and further obstruction by high energy in direct path

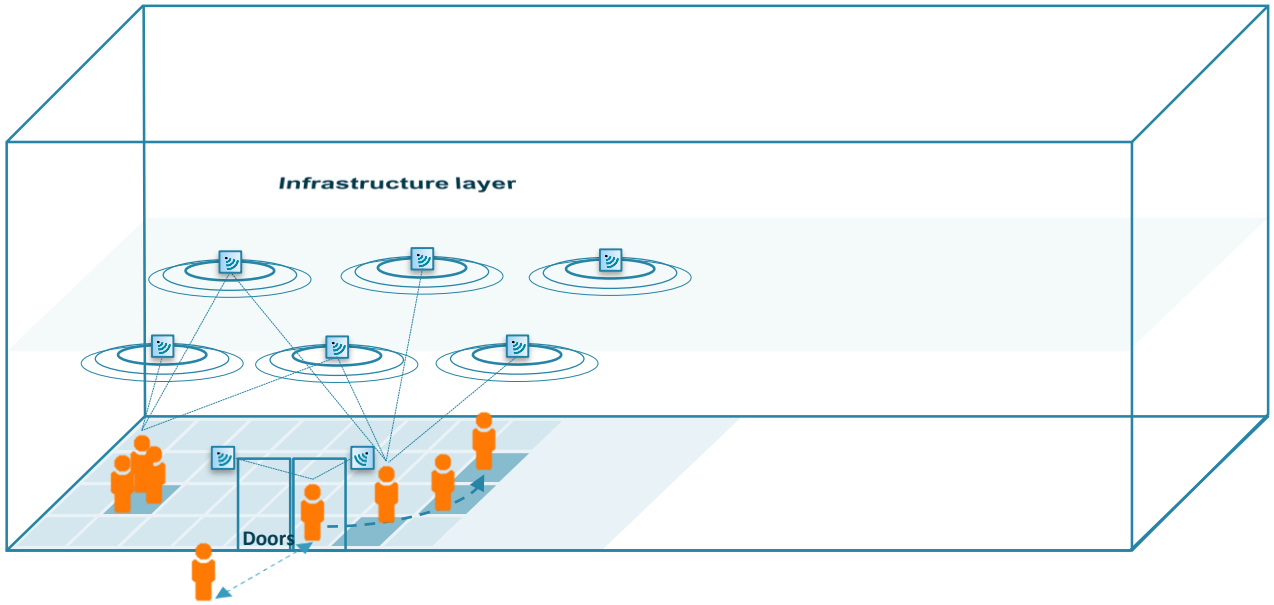
Active Reflector

- Objects of Interest are actively engaged in radio traffic and corresponding measurement process
- Active RFID Application
- ☹ Requires extra HW and energy reservoir for Objects of Interest
- ☺ Usually higher SNR due to evaluation of direct propagation paths

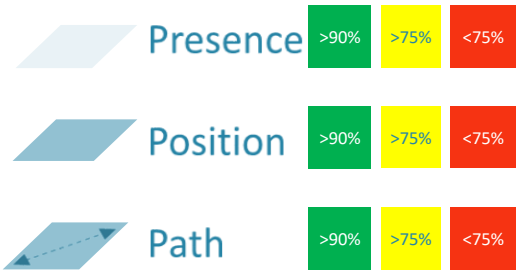




From Proximity over Movement to Radar Imaging

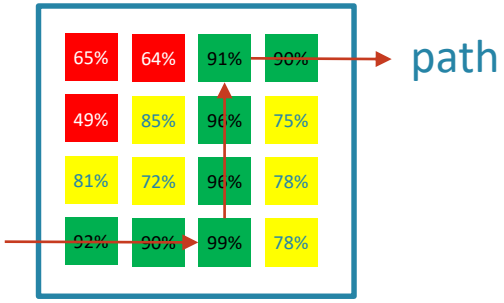


Confidence level of a detected event in a sector of the covered area



Monitored area is divided into a grid

The presence and movement of people can be detected



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WE KNOW THE DISTANCE !

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