



Das Netz der Netze – Und seine Bedeutung für die Digitale Landwirtschaft

Gerhard P. Fettweis – Vodafone Chair Professor – TU Dresden

vodafone chair @ TU Dresden: Key Facts & Figures

The Team

- 1 Professor
- 8 Senior scientists/lecturers
- 3 Post-docs
- 40 Ph.D. students
- 15+ Master students
- 3 Program managers
- 12 Start-up incubator employees
- 2 Secretaries
- 7 Lab engineers

IPP Sponsors



Accomplishments

Scientific:

- 83 Ph.D. grads
- 270+ Ms. grads
- 900+ publications
- 17,500+ citations
- 200+ patent appl.
- 85+ patent families

Innovation:

- 16 spin-outs
- 300 engineers

Funding:

- € 60M Chair
- € 60M VC
- € 1/2B projects



Project Partners



The Vodafone Chair's Startup History

1999 OnDSP™ based WLAN chip-sets



2002



2000 SON systems



2006



2003 Broadband Wireless HW (LTE,...)



2012



2004 Module and reference board design



2006



2005 MPSoC semiconductor IP



2007



2007 Wireless audio



2008 Network performance measurement



2016



2008 LTE Cellular Handset Chip IP



2012



2010 Satellite Communications



2017



2012 Startup incubation and growth partner



2013 Assisted living & IoT



2013 Bitcoin harvesting engines



2013 Massive MIMO Cells



2014 Machine vision for manufacturing



2015 Cellular IoT Chip IP



2018

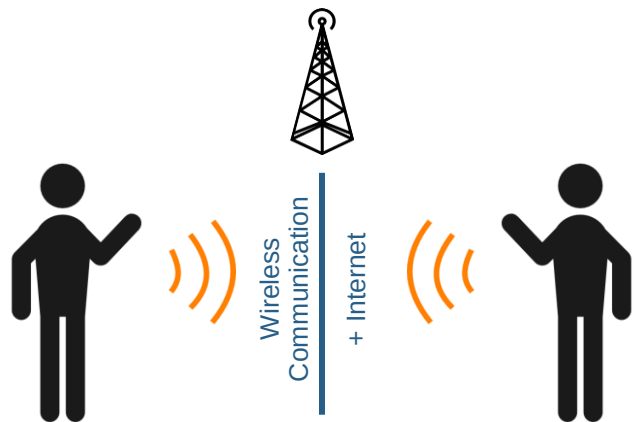


2016 Telemetry for IoT



Farming

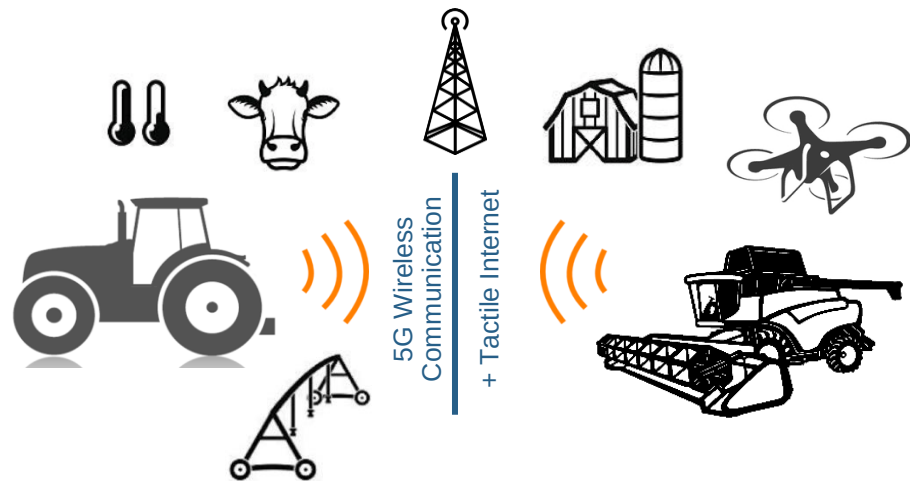
Bis heute



Human to Human

Focus: Spectral Efficiency

Zukunft



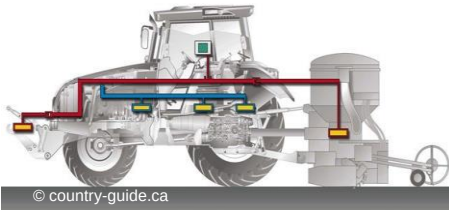
Machine to Machine

Focus: Massive (>50B IoT devices, 2020)
+ Tactile (<1ms Latency)

Communication Ranges – Coverage

Classification of Technologies

Ultra-Short-Range



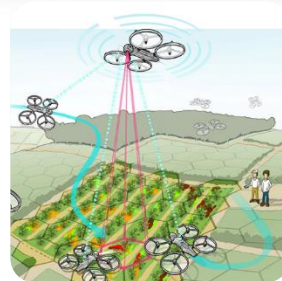
Mid-Range



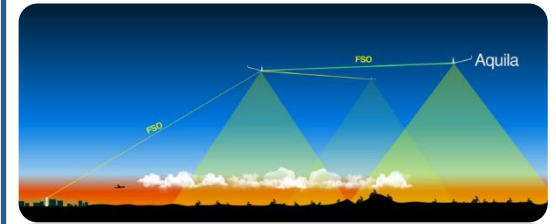
Long-Range



Short-Range



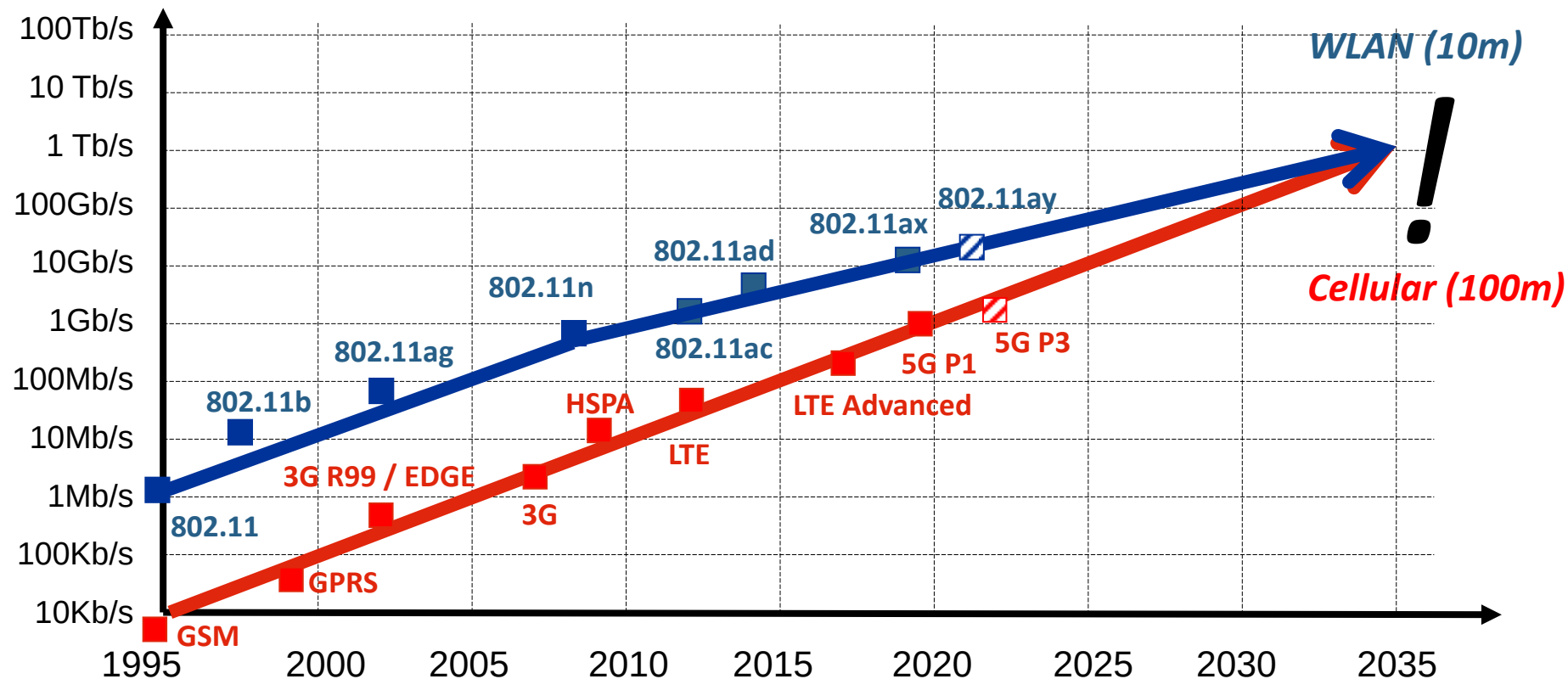
Ultra-Long-Range



Rural Coverage?

Germany's Challenge

The Wireless Roadmap >2020 Outlook



Data Rate – How to Achieve Increase?

10 kb/s reception → receive signal must dominate over noise power

„SNR“ (*signal-to-noise-ratio*)

GSM: typ. 10km cell radius

10kb/s → 1Gb/s requires 100'000x increase in transmit power?

1st Approach

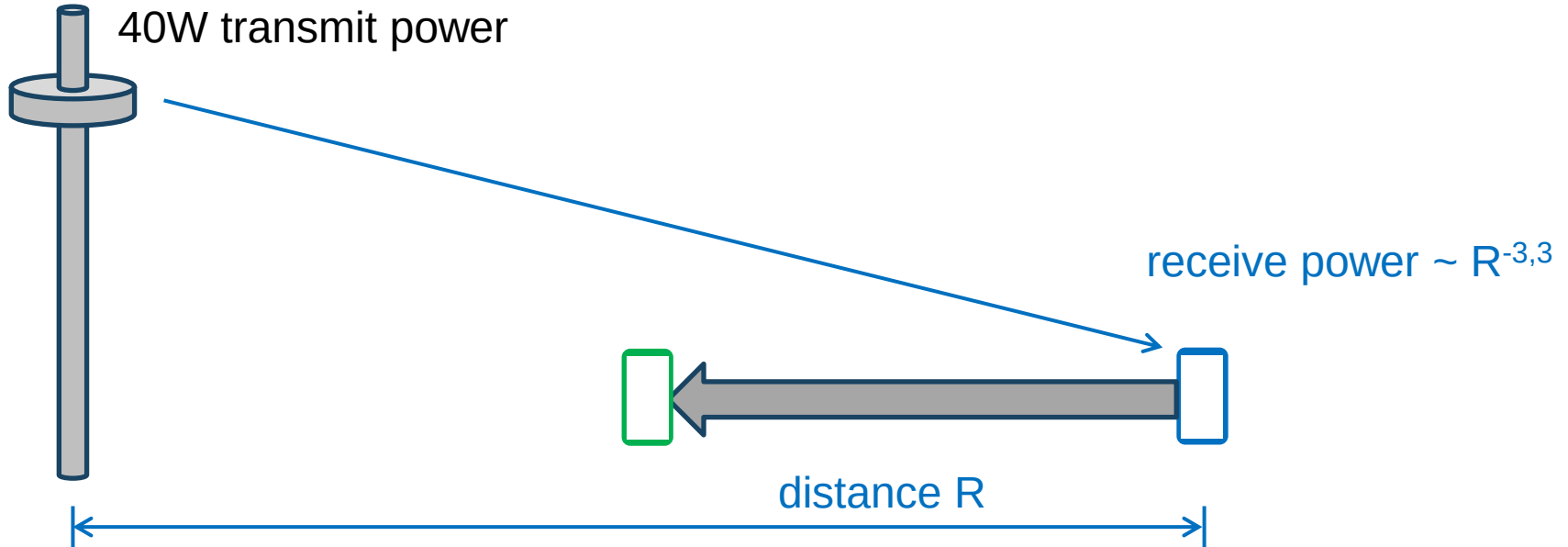
Improved Signal Processing

Using ideas equivalent to e.g. „headset with noise cancellation“

→ 10x

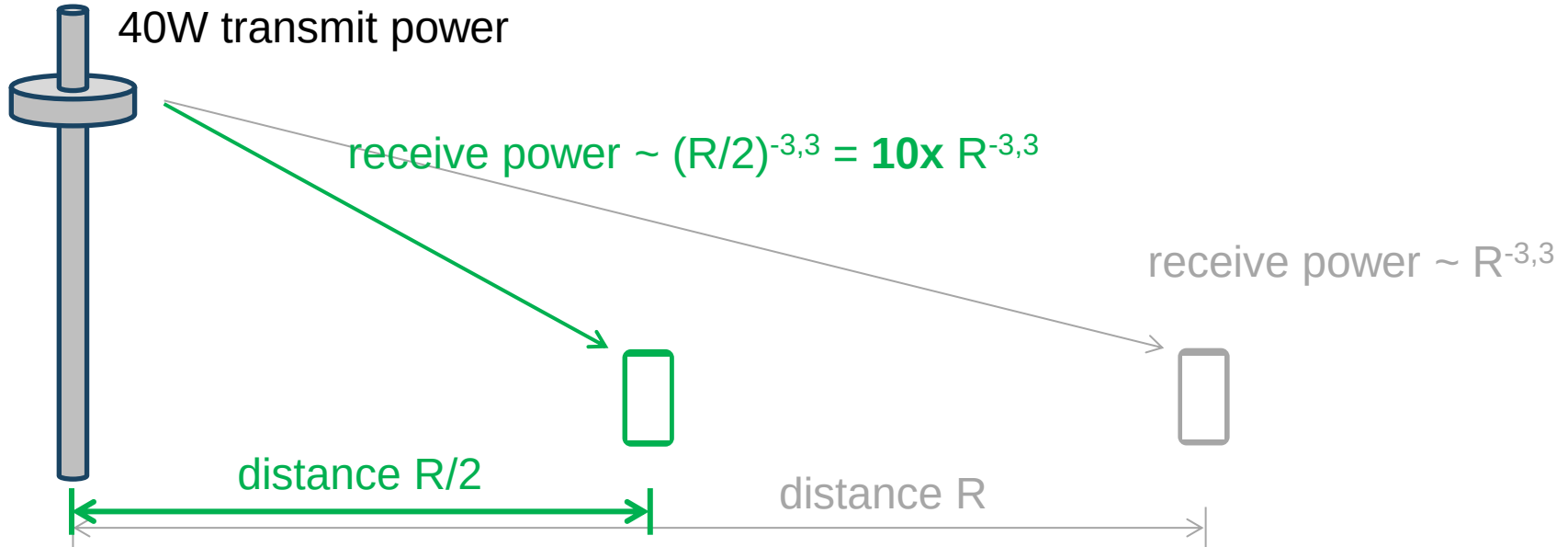
2nd Approach

Cell Densification

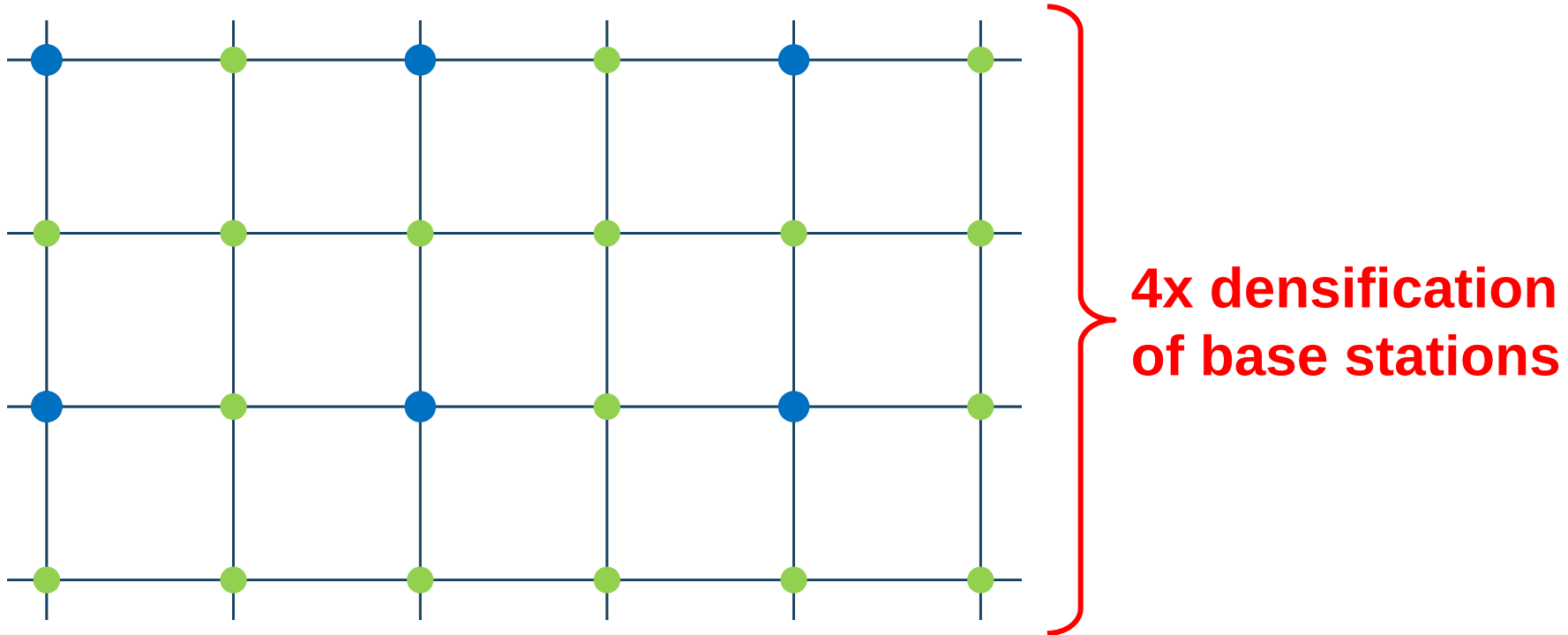


2nd Approach

Cell Densification



Example – Halving Distance



Conclusions – Cell Densification

Urban $\sim R^{-3,3}$

Rural $\sim R^{-2,3}$

Urban 10x data rate → 4x cell densification

Rural 10x data rate → 8x cell densification

Urban 1000x data rate → 64x cell densification?

Rural 1000x data rate → 512x cell densification???

Conclusion: massively deploy fiber !

However: high data rates not deployable in rural areas ?!

3rd Approach

Carrier frequency

500MHz versus 2,5GHz → increase of reach e.g. „10x“

However – terrestrial TV hogging best UHF frequencies under 1GHz

4th Approach

Base station antenna height

10m → 100m → 10x (and more)

→ Rural advantage



NEW: 5th Approach

Antenna gain via „massive MIMO“

Use planar antenna arrays

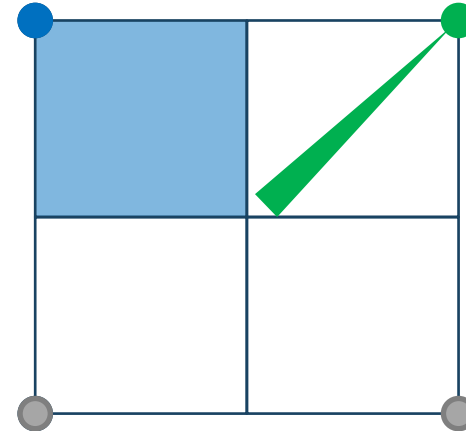


Transmitting: „Illuminate“ less area, i.e. focus beam @ same transmit power

Receiving: „Focused listening“

→ 100x

→ larger antennas → rural advantage!



Concluding: 100'000x Data Rate

1Gb/s per user at base station: fiber backbone !!!

100'000x data rate

Signal processing: ca. 10x

Mast height ca. 10x

+ cell densification 1000x ? Rural $8 \times 8 \times 8 \times = \text{ca. } 500\text{x more cells}$

Massive MIMO: ca. 10x by 2020, (100x starting 2025)

➔ only 10x cell densification required

➔ or no densification by using UHF <1GHz

Spectrum

Germany's Challenge

Germany's Coverage Challenge – Frequency Licensing

€€€ Auction

1. Large upfront expense → CFO in charge
2. Kills chance to deliver rural coverage (CFOs in charge: rollout restricted)
3. Kills industry (CFOs in charge: suppliers are squeezed)
4. Returning to monopolies (redistribute auction income to incumbent)

Beauty Auction

1. Service delivery promise → CTO in charge
2. Delivers service as required (CFOs must empower CTOs to adhere)
3. Maximizes network rollout (CFOs must empower CTOs to adhere)
4. Innovation driver (CTOs in search of solutions)

Tactile Internet

Germany's Challenge

The Tactile Internet

Moving from 50ms round-trip time → 1ms tomorrow



<http://ostsee-spezial.de/?p=148>

Gerhard Fettweis

Revolution Ahead: The Tactile Internet



5G:
Ubiquitous
Steering & Control
Communications

Health & Care
Traffic & Mobility
Sports & Gym
Edutainment
Manufacturing
Smart Grid
...

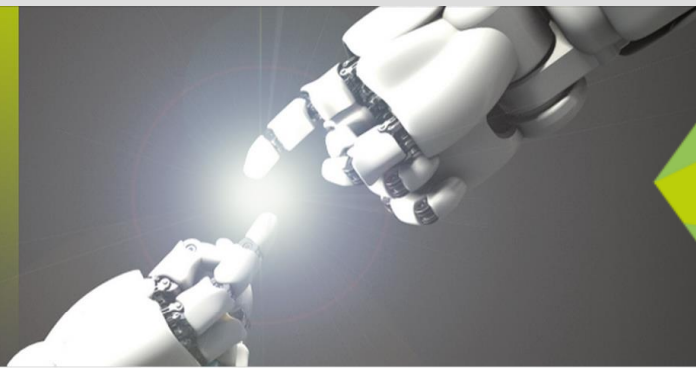


$\leq 4G$:
Ubiquitous
Content
Communications

IoT
Internet of Things
...



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5G LAB
GERMANY



vodafone



ROHDE & SCHWARZ



NOKIA



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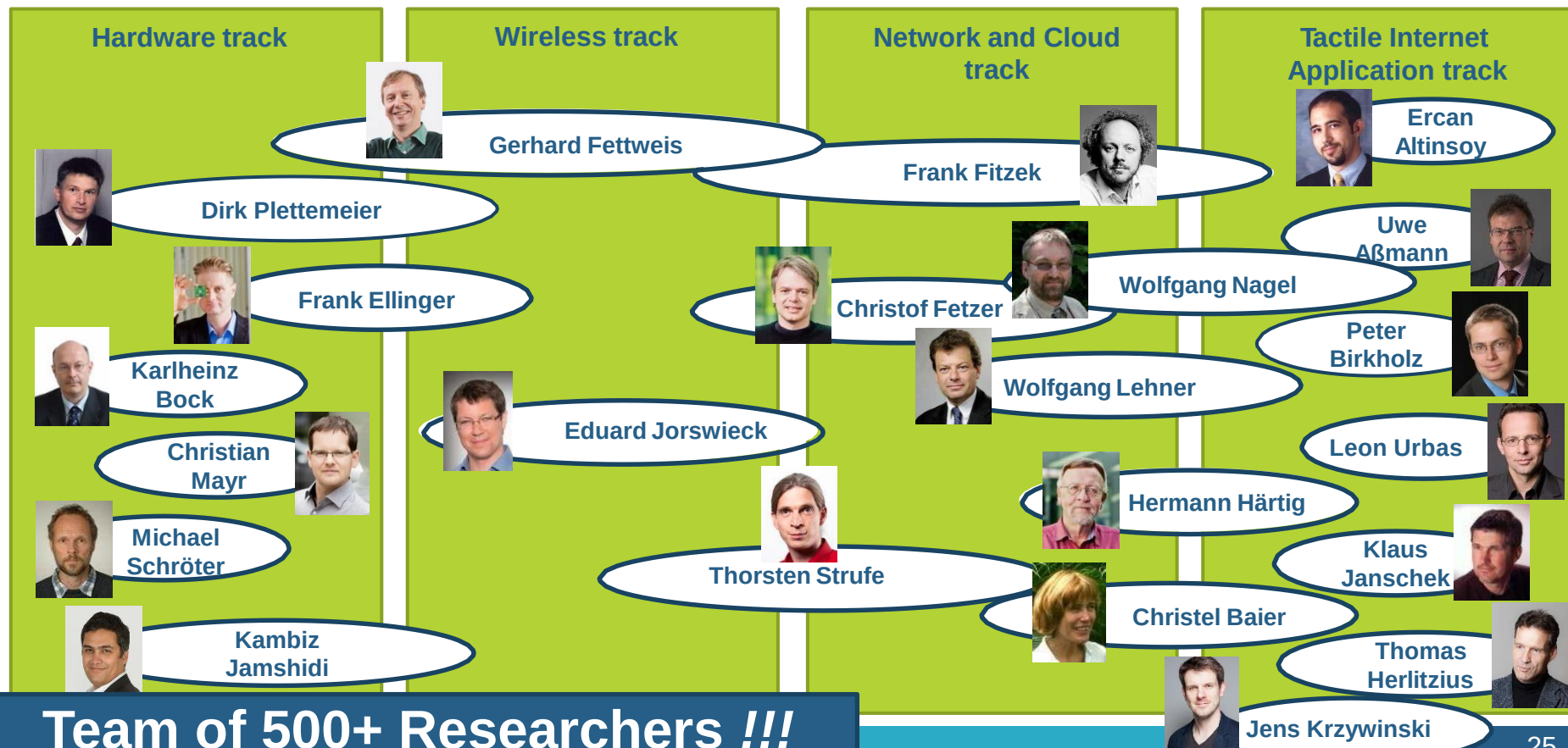
VOLKSWAGEN

AKTIENGESELLSCHAFT

SYNOPSYS

coming soon

5G Lab Germany Members



Precision Farming

Mid-Range Communication

25m – 1.000m



Drone can also
act as a **relay
station**

Single- or Multi-hop
communication



Cooperative machines, monitoring of process data,
remote control, connecting drones to machines and process automation



The Future Precision Farming Machine



Mid-to-Long-Range Communication 25m – 5.000m

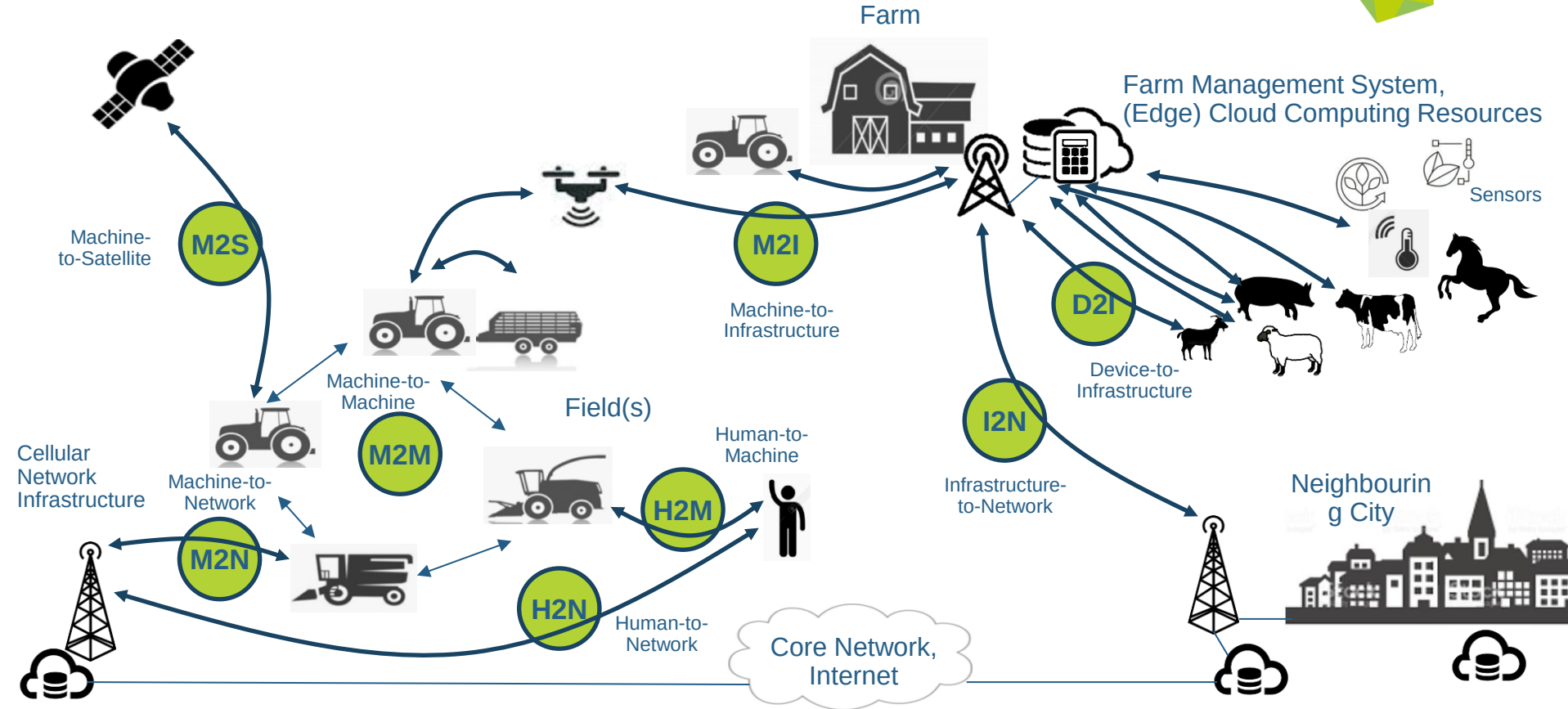
Tactile Internet Farming Robots



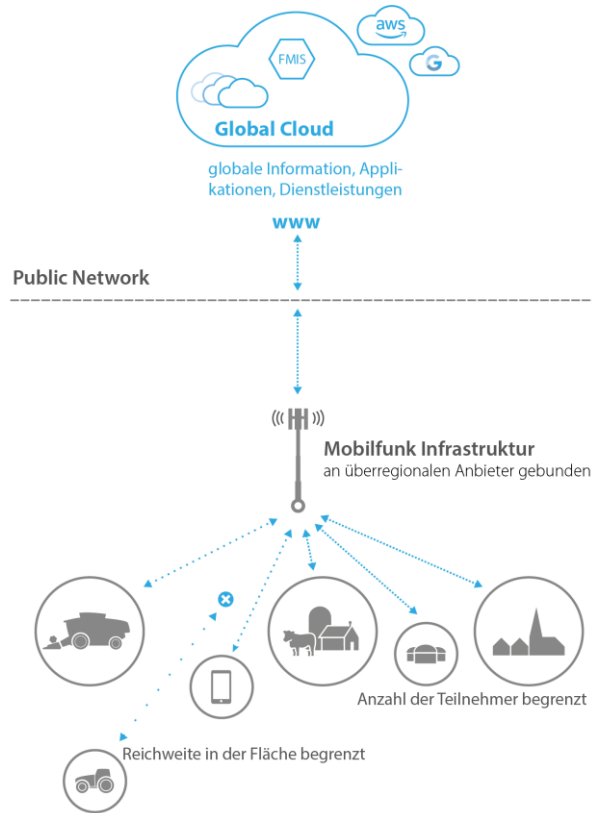
- Autonomously operating
- Remotely controllable
- Continuously monitorable
- M2M capabilities for collaborative operations
- Can be supervised by Cloud

Farming 4.0

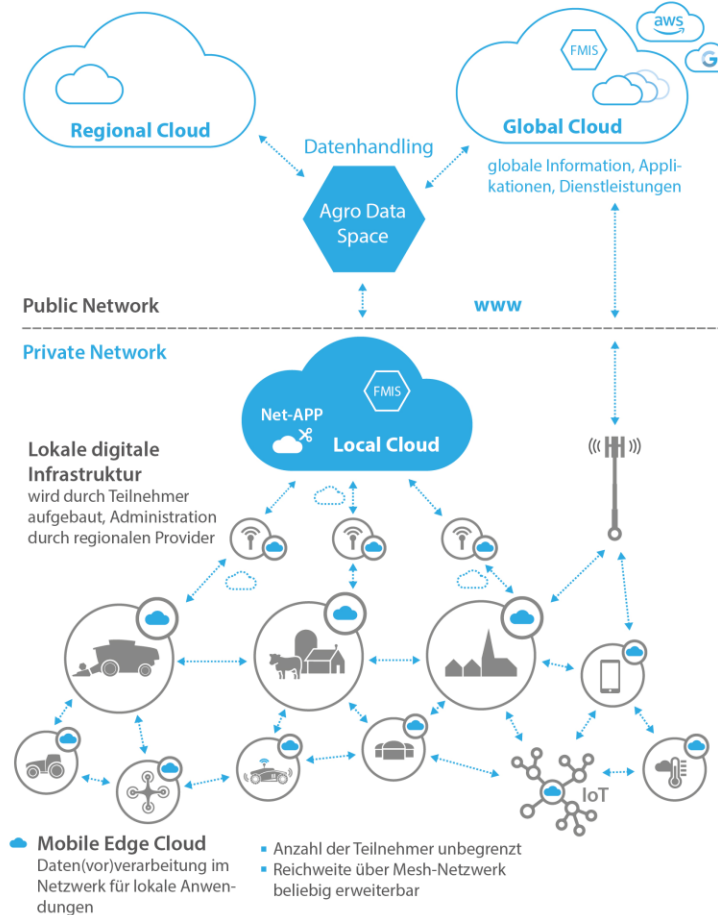
Digitale Kommunikationstechnologien



GEGENWART



ZUKUNFT



Conclusions

5G – Only The Beginning: “The Carl Benz Automobile” for the Tactile Internet





5G

?

6G

¥€\$

£ots of Opportunities of 5G Ahead
Starting Now !!!

1. 5G ermöglicht „Condition Monitoring“ zur Steigerung von Ertrag und Umweltverträglichkeit
2. Diese „Roboterisierung“ des Taktilen Internets ermöglicht deutliche Fortschritte
3. Das Taktile Internet wird Umweltverträglichkeit und Ertragskraft deutlich steigern
4. Die Kompetenz der Landwirte muss entsprechend weiterentwickelt werden
5. Die Landwirtschaft benötigt eigene Ad-Hoc-Funknetzlösungen
6. Lokale Cloud-Installation ermöglichen Symbiose von Mobilfunk und eigenem Ad-Hoc Netz
7. Deutschland hat Pole-Position im Rollout und Zulieferkette des Taktilen Internets für die Landwirtschaft
8. Eine koordinierte Aktion der Landwirtschaft, der Landtechnikindustrie, und des Bundes kann Pole-Position hier weichenstellend für Deutschland sichern

Thank You



for 23 years of continued support !