Wireless Communication for Modular Production Facilities
Drahtloskommunikation für modulare Produktionsstätten

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Changing Lot Size

"A customer can have a car painted any color he wants as long as it's black."

Henry Ford, 1909

Source: RONDO Burgdorf AG

Source: SmartFactory KL

Production control

- Today:
  - Cable based communication of all actuators, sensors and controllers
- Future:
  - Increase in wireless sensors, actuators and controllers

	Centralized	Decentralized
Control	One central control entity	Intelligent workpiece (carriers)
Object identification	Passive object identiefier	
Wireless Communication	AGVs	AGV, infrastructure and workpiece carriers

Requirements for Wireless Communication

	Production System	Mobile Robots	Wireless Sensor Network
Data rate	10 Mb/s	10 Mb/s	Combined: 100 Mb/s
Latency	4 ms cyclic 10 ms acyclic	1 ms cooperative motion control 1-10 ms machine control 10-50 ms for cooperative driving 10-100 ms for video operated remote control 40-500 ms traffic management and support systems	5-10 ms safety critical Up to 1 s for event-based monitoring
Availability	99.9999%	99.9999%	99.999% 99.9999999% (safety critical)
# of Nodes		>100	10^6

Current Technologies – WPAN and WLAN

	Bluetooth		ZigBee	Wi-Fi	
	Classic	LE		a/b/g/n	ah
Standardization	IEEE 802.15.1		IEEE 802.14.1	IEEE 802.11	
Frequency band (Europe)	2.4 GHz		868 MHz / 2.4 GHz	2.4 GHz / 5 GHz	868 MHz
Nominal range	10 m		100 m	100 m	1 km
Max. nodes per cell	8	32767	65536	2007	8191
Max. data rate	1Mb/s	2 Mb/s	250 Kb/s / 20 Kb/s	150 Mb/s*	7.8 Mb/s
Latency	<100 ms	<3 ms	<5 ms	25 ms	
Topology	D2D, star	D2D, star, mesh	Star, tree, mesh	Star, tree, mesh, D2d	Star, tree

* Single antenna

Current Technologies – WMAN

	LTE		
	LTE classic	eMTC	NB IoT
Standardization	3GPP		
Frequency band (Europe)	800 MHz/ 1.8 GHz/ 2.6 GHz		
Nominal range	5 km		8 km
Max. nodes per cell	400	>50000	
Max. data rate	100 Mb/s	1 Mb/s	250 Kb/s
Latency	20 ms	10-15 ms	1.6-10 s
Topology	star	star	star

5G New Radio

- Specifications for 5G NR*:
  - >10 Gb/s (xMBB)
  - 1,000,000 devices per km^2 (mMTC)
  - >99.999% availability
  - <1 ms latency (URLLC)
  - >10 a battery lifetime
  - D2D Communication
  - Network Slicing

Source: Nokia

*Source: 5G ACIA White Paper & Nokia 5G Masterplan White Paper

Private Cellular Networks

- Usage of ISM spectrum protocols in licensed spectrum
- Cellular base station directly integrated in company network
- Advantages:
  - Lower latencies
  - Better privacy/confidentiality

- Challenges:
  - Regulations are not clear yet (Direct sprectrum licensing or sub licensing from telecommunication companies)

Conclusion

- Currently no one-size-fits-all solution
  - Modular factories can be implemented with heterogenous communication technologies, with
  - Expensive due to amount of different technologies needed

- 5G NR promises to meet all requirements
  - Extending URLLC capabilities with Release 16
  - Using SDN and NFV for coexistence of conflicting requirements
  - Private radio to achieve latencies and meet privacy concerns

Thank you!