Beckhoff – The Application Prospect of 5G Wireless Communication in Smart Factory

德国倍福——5G无线通讯在智慧工厂的应用前景

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BECKHOFF New Automation Technology—— A constitutor and promoter for industrial international standards

德国倍福－国际标准的制定者和推动者

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- The initiator and main promoter of **PC Control technology**: an unique control system besides PLC and DCS
- ✓ PC 控制技术的倡导者和主要推动者：继PLC和DCS之后独树一帜
- The pioneer and main promoter of **Open CNC system**: another way to control non-standard equipments
- ✓ 开放式数控系统的倡导者和主要推动者：为非标设备控制另辟蹊径
- The supporter and main promoter of **IEC61131-3**: important member of PLCopen organization
- ✓ IEC61131-3 的倡导者和主要推动者：PLCopen 组织的重要成员
- The founder-member and main promoter of **OPC UA**: serving as the global vice president of OPC Foundation
- ✓ OPC UA 的发起人和推动者：任OPC基金会全球副主席
- The developer and leading promoter of **EtherCAT** the industrial Ethernet fieldbus (IEC, ISO, SEMI, GB/T 31230.1~6-2014): Advancing the technology and chairing the member organization (EtherCAT Technology Group, 5,000 members)
- ✓ EtherCAT 工业以太网总线的研发者和推动者：任ETG(EtherCAT Technology Group, 5,000 members)全球主席
- 5G Alliance for Connected Industries and Automation (**5G-ACIA**): founder-member
- ✓ 工业物联与自动化5G联盟：创始会员

PLCopen
for efficiency in automation

OPC FOUNDATION

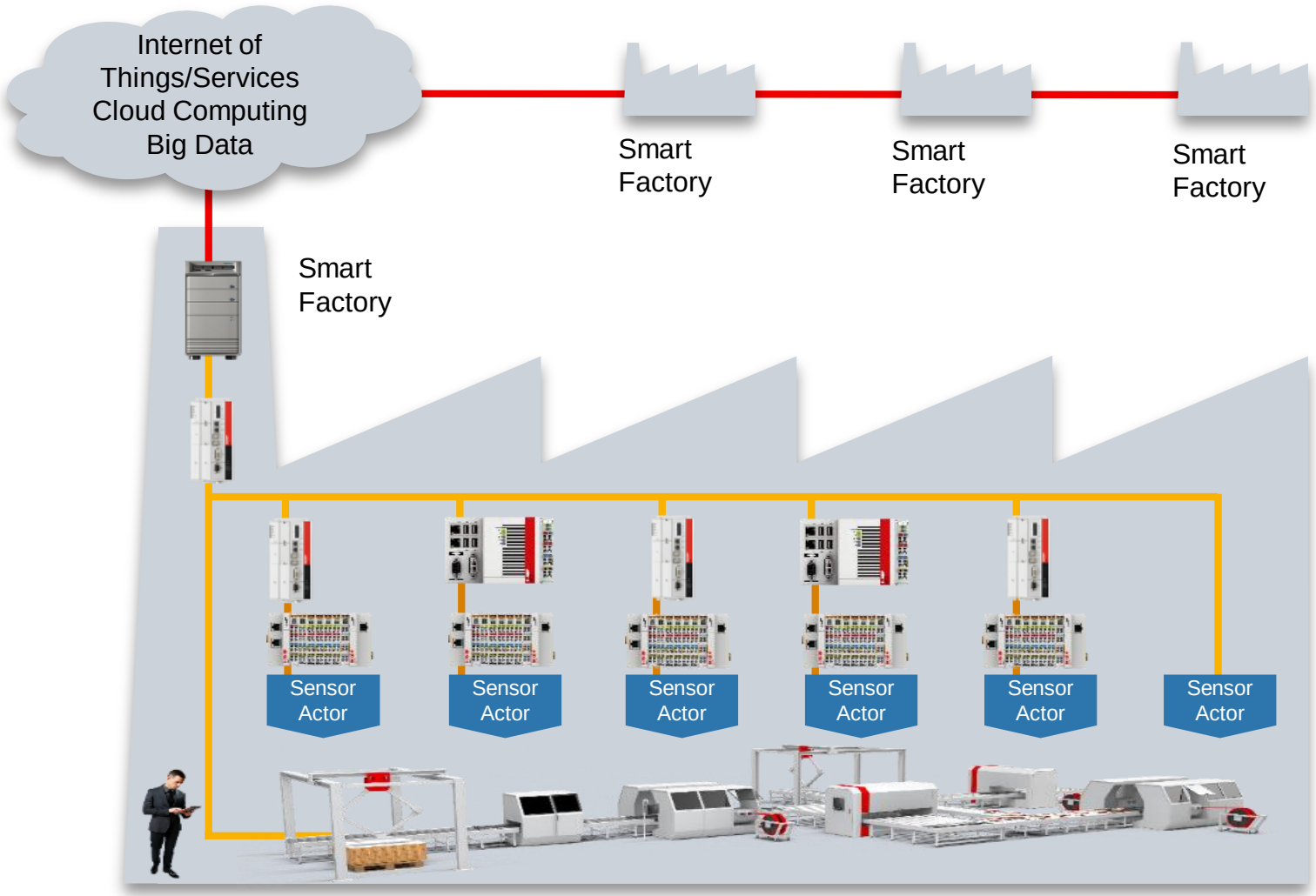
EtherCAT®

PC based Control - Core technology for the smart factory
PC 控制——智慧工厂的核心技术

Networking of products, production means and facilities along the global value chain

全球价值链中的产品、生产资料和生产设施的网络化

- Secure horizontal and vertical communication
- ✓ 安全的水平和垂直通信
- Central cyber physical data collection, analysis and interpretation (Big Data)
- ✓ 中央信息物理数据采集、分析和解析（大数据）
- **consistent and integrative engineering across the entire product lifecycle**
- ✓ 贯穿整个产品生命周期的一致性和一体化的工程
- human being as central switchpoint of the networked production
- ✓ 人作为网络化生产的中心点



Control level in Smart Factories
智慧工厂中的控制层级

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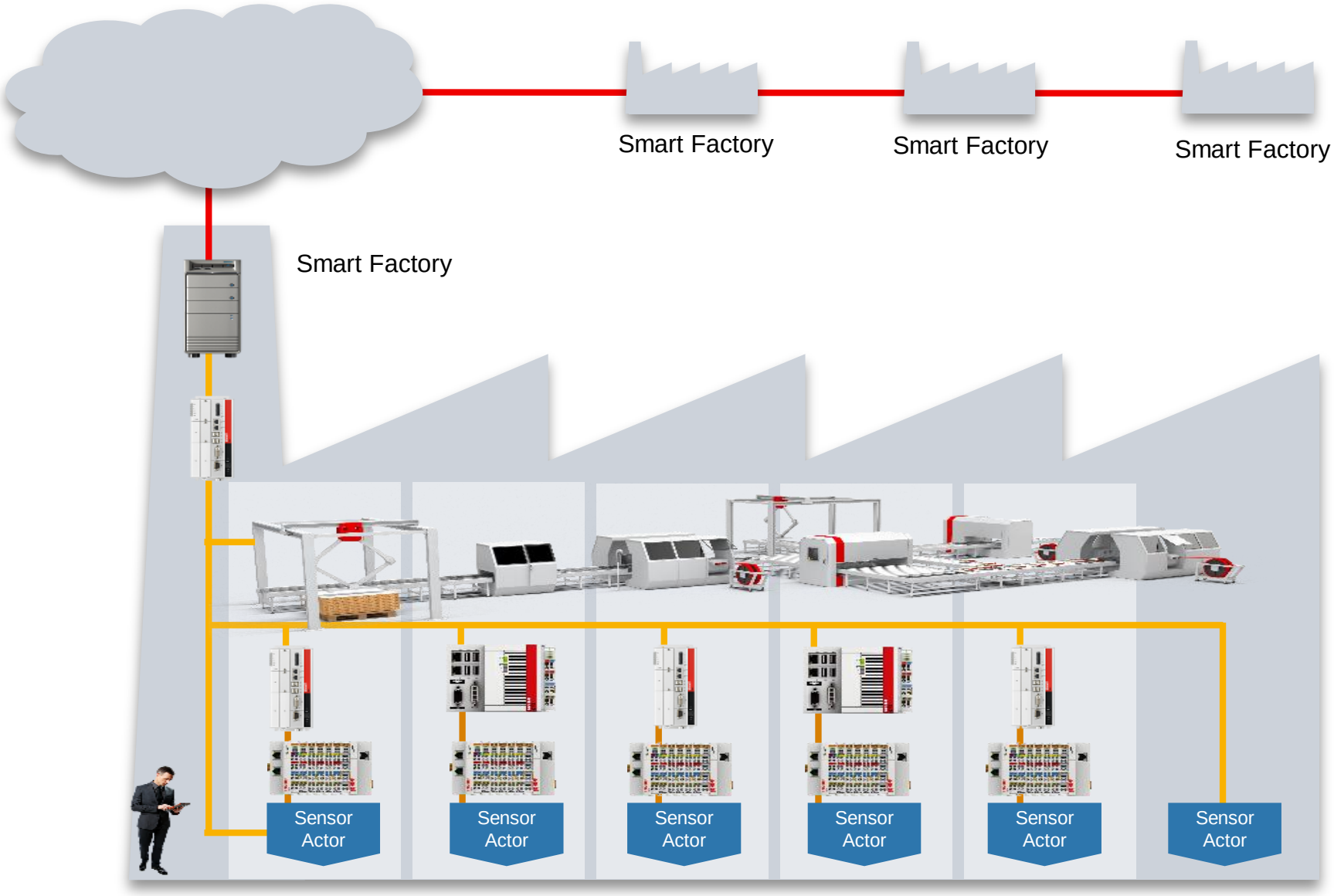
Global Cloud（全球云）
Cloud Control
云控制

Local Cloud（本地云）
Edge Control
边缘控制

Plant level（工厂层）
Line Control
生产线控制

Machine level（机器层）
Machine Control
机器控制
Sensor / Actuator
传感器/执行器



Communication Layer in Smart Factories
智慧工厂中的通信层级

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Global Cloud（全球云）

Broker

Local Cloud（本地云）

IP

Plant level（工厂层）

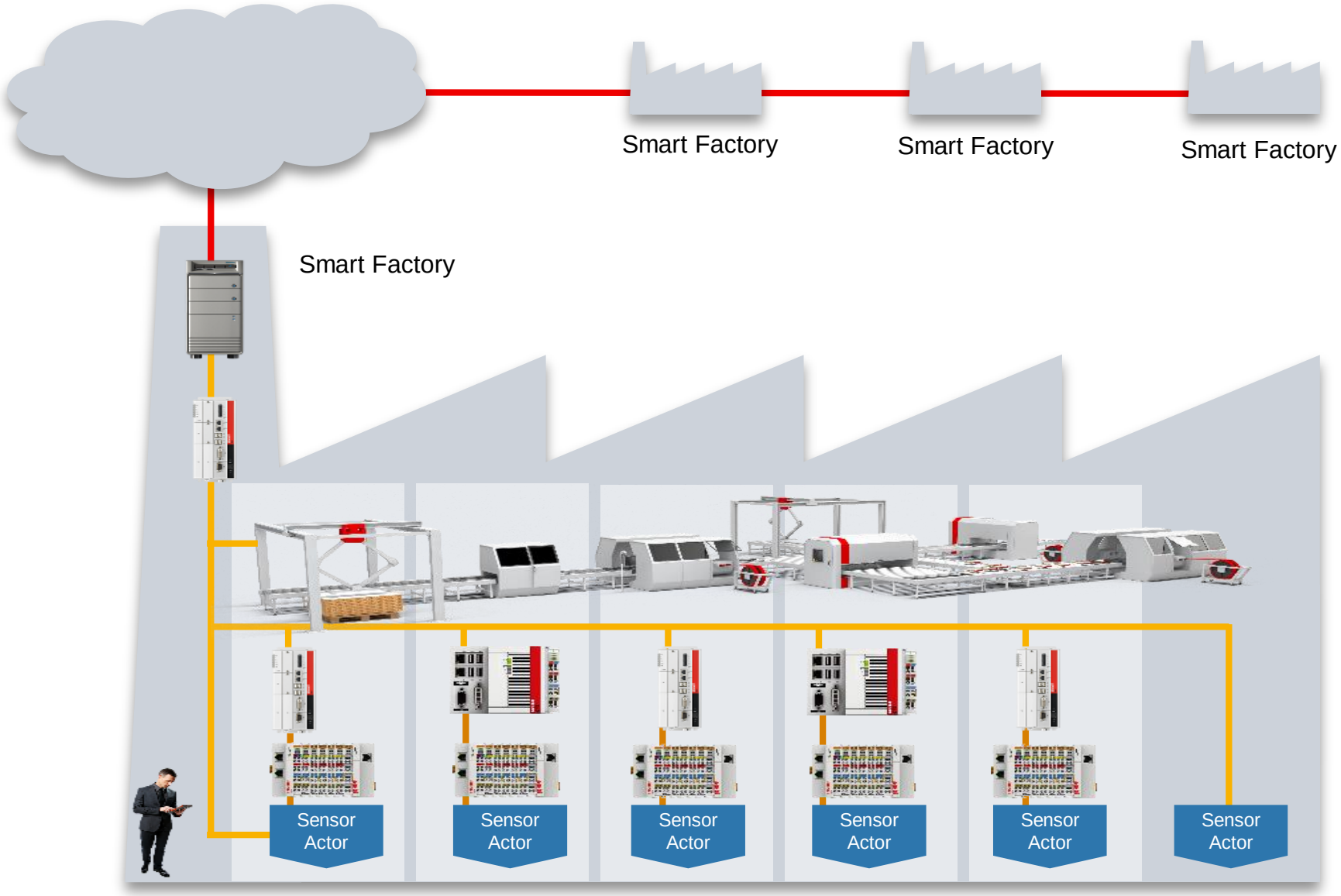
Router / Switches

Controller-Controller

Machine level（机器层）

Fieldbus

现场总线



Requirements for Machine I/O Network
机器I/O网络中设备的通信要求

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- Connected devices

	Cycle Time 周期时间	Communi-cation Time 通信时长	No. of devices 设备数目	Process Data 过程数据 In 输入 [Byte per device] 每个设备字节数	Process Data 过程数据 Out 输出 [Byte per device] 每个设备字节数
Motion Control **运动控制**	62,5 µs **125 µs**	10 µs **10 µs**	8…64…128 8…**64**…128	16 **16**	16 **16**
PLC Control **PLC控制**	62,5 µs 125 µs **1 ms** 10 ms	10 µs 10 µs **100 µs** 1 ms	8…64…128 8…64…128 **64…1024** 64…1024	1…8 1…8 1…**8**…128 1…8…128	1…8 1…8 1…**8**…128 1…8…128
Measure-ment **测量**	**125 µs** 1 ms 10 ms	**10 µs** 100 µs 1 ms	8…64…128 64…**1024** 64…1024	1…8…128 1…**128**…1k 1…128…1k	1…8…128 1…8…**128**…1k 1…8…128…1k
Vision **视觉**	1 ms 10 ms 25 ms	100 µs 1 ms 1 ms	1…16…64 64…1014 64…1024	1…8…64 1…8…64 1…8…64	10kByte…4MByte 10kByte…4MByte 10kByte…4MByte
HMI	1 ms **10 ms** 25 ms	100 µs **1 ms** 1 ms	1…16…64 1…**16**…64 1…16…64	128…1k 128…**1k**…10k 128…1k…10k	1…8…64 1…**8**…64 1…8…64

Wireless Network for Industrial Automation
工业自动化中的无线网络

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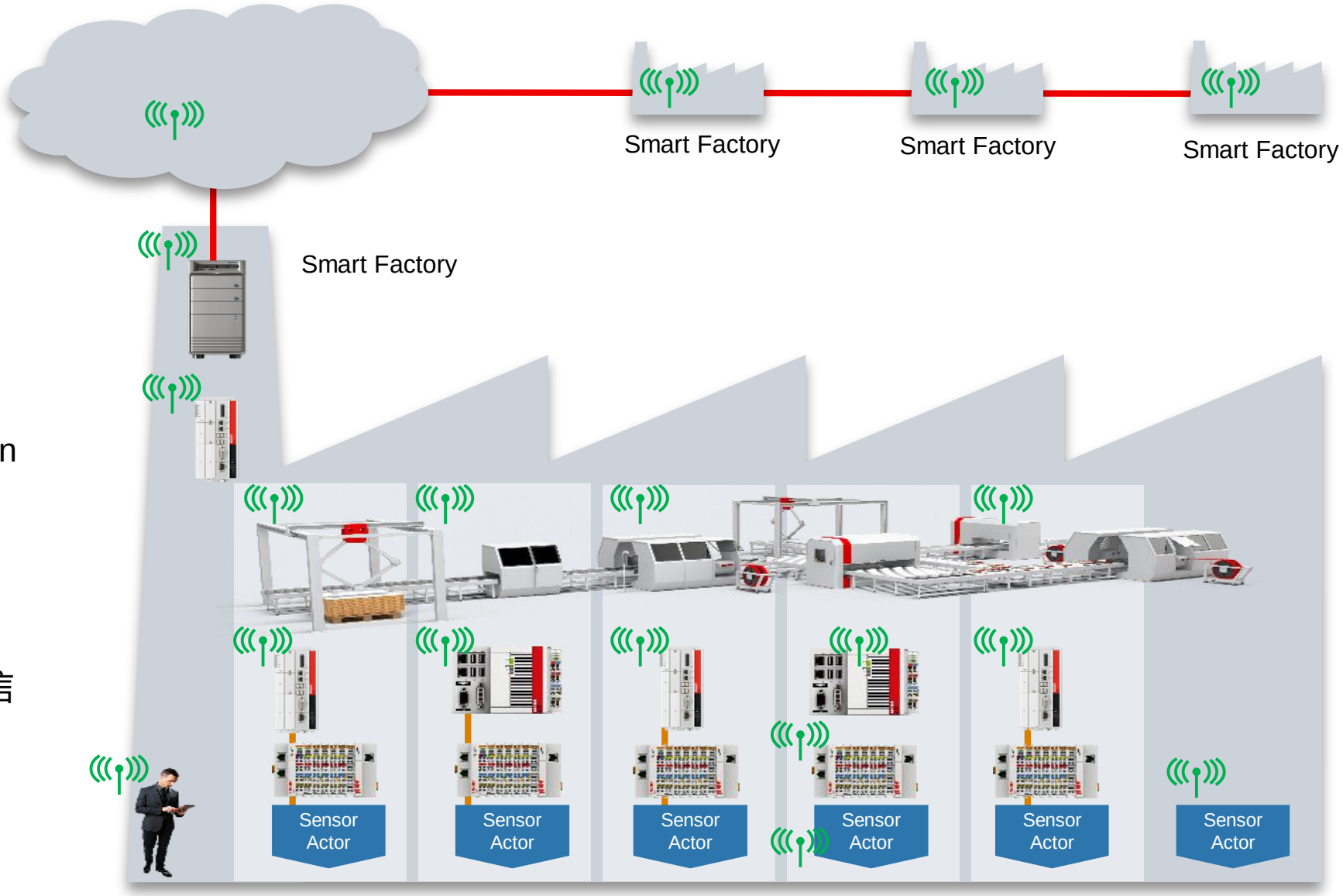
5G for
- Replacement of cable connections
✓ 替换有线连接

- Secure horizontal and vertical communication
✓ 安全的水平和垂直通信

- Machine communication with Low Latency and high Reliability
✓ 低时延和高可靠的机器通信



Local Wireless I/O Network
本地无线I/O网络

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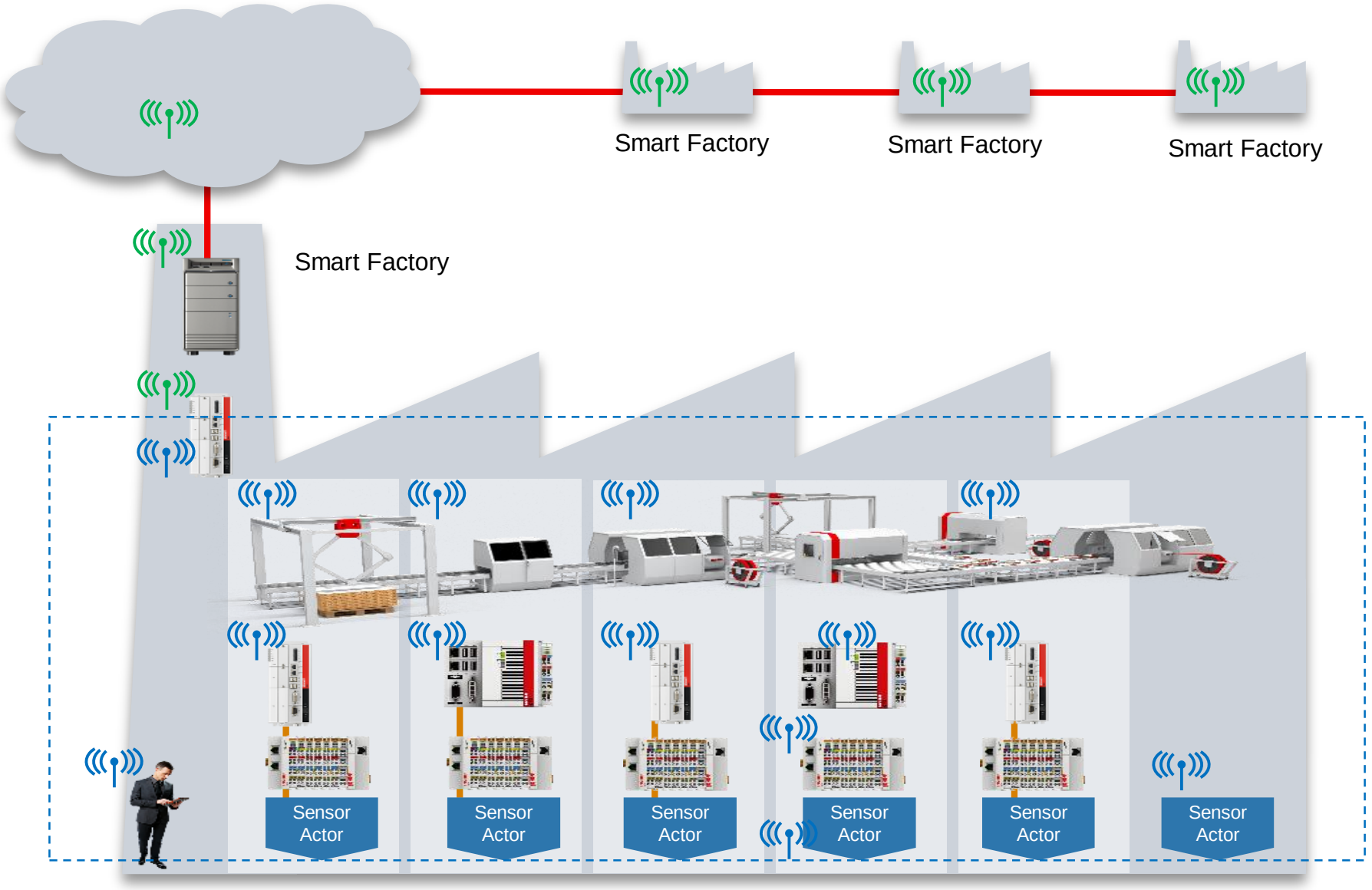
Local Factory
Wireless I/O Network
本地工厂无线I/O网络

- Reserved Spectrum
✓ 预留频段
- License Free
✓ 免授权



Functional Requirements
功能要求

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- Synchronization 同步性
  - Accuracy better 100 ns 精度高于100ns
    Jitter < 100 ns 抖动< 100 ns
  - Timestamping 时间戳
- Easy Configuration 易于配置
  - consistent and integrative engineering across the entire product lifecycle
- Reliability 可靠性
- Secure horizontal and vertical communication 安全的水平和垂直通信
- Functional Safety 功能安全
  - Black Channel approach with safety protocol like Safety-over-EtherCAT
  - ✓ 使用黑箱通道传输类似Safety-over-EtherCAT的安全协议
  - Deterministic communication pre-condition 确定性的通信是必要的先决条件
- Diagnosis 诊断
  - Monitoring of network throughput and localization of failures 监控网络吞吐量和定位错误
- Price communication interface 价格
  - Hardware / Software per device <10€
  - License costs factory network 0€

Basic service requirements of industrial use cases
工业应用场景中的基本服务需求

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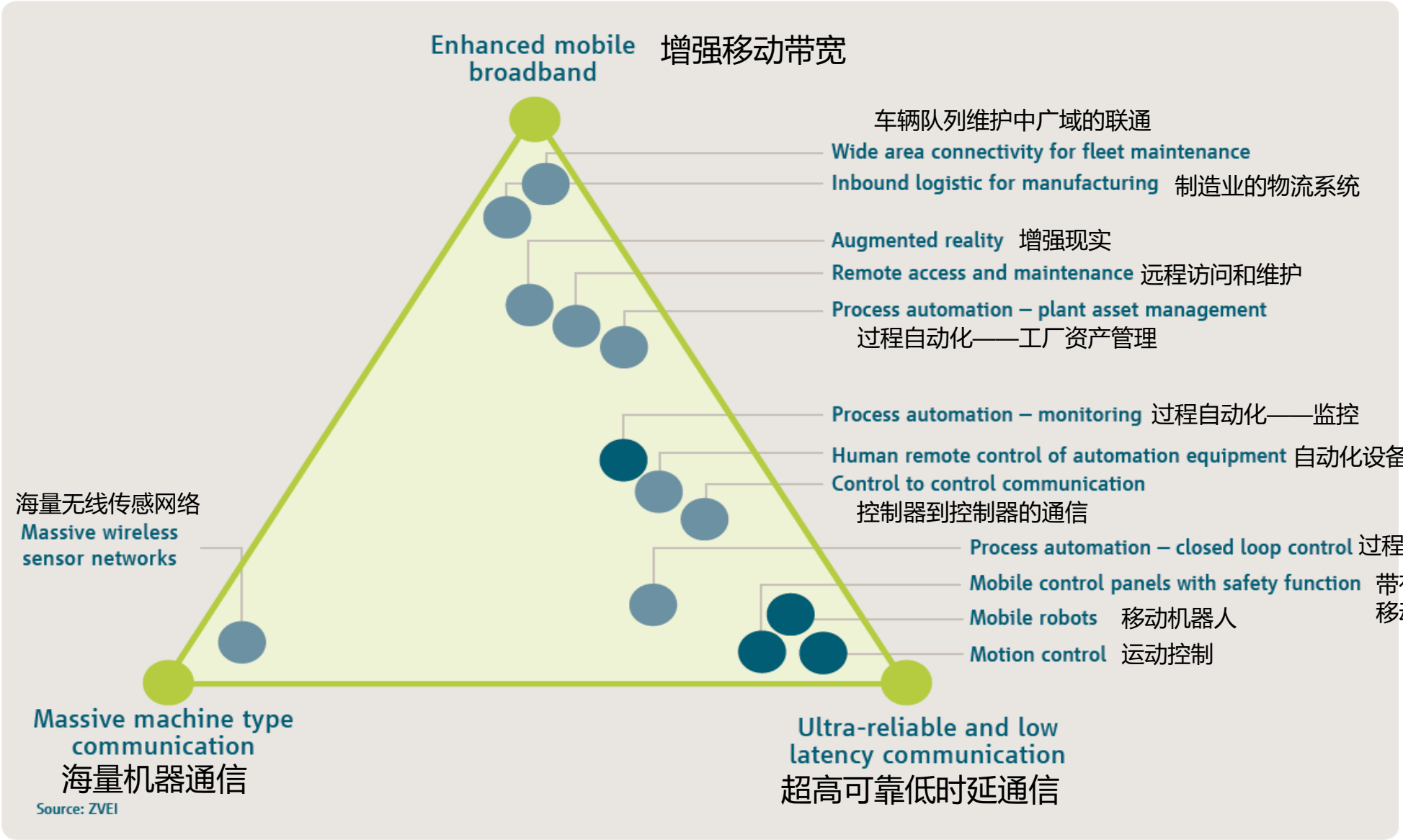

5G Wireless Demonstration on Hannover Messe 2018
2018汉诺威自动化展上的5G无线通信演示

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5G Wireless Demonstration on Hannover Messe 2018
2018汉诺威自动化展上的5G无线通信演示

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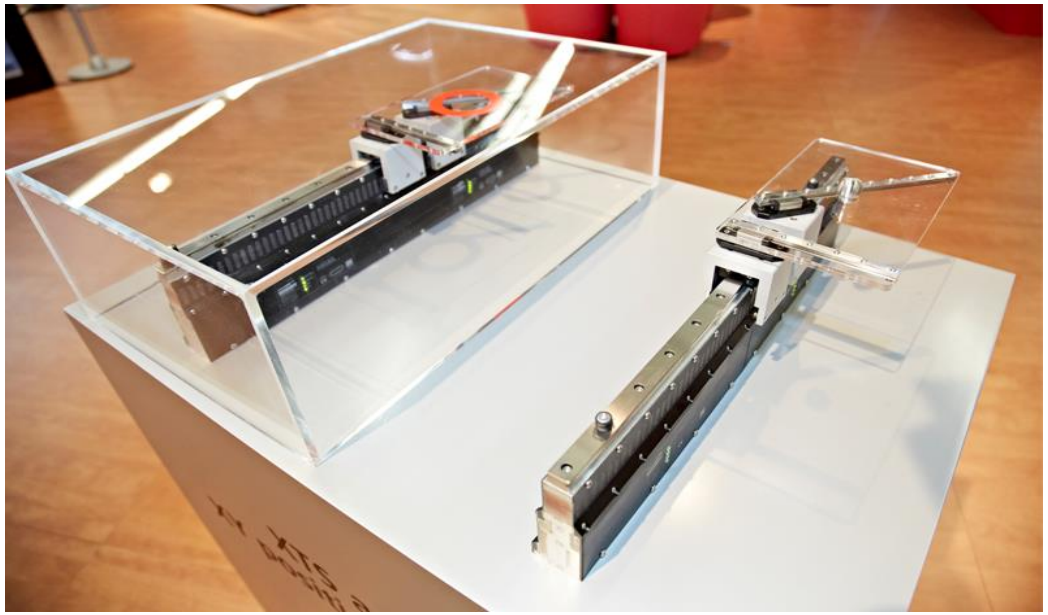
- Real-time wireless communication to mobile or remote control PLC
- ✓ 与移动或远程控制PLC的实时无线通信

- Machine units connected via 5G wireless communication 通过5G无线通信连接机器单元
  - Cyclic exchange of Layer 2 Ethernet Telegrams 周期性交换第2层的以太网数据报文
  - EtherCAT Automation Protocol (EAP) with 2ms NC cycle time 2ms NC周期时间的EAP通信

- Huawei 5G devices 华为5G设备
  - Latency: 1 ms@130 Byte (one direction)
    URLLC: Ultra-Reliable Low-Latency Communication
  - ✓ URLLC：超高可靠低时延通信
  - Parallel Video-Streaming 并行的视频数据流
    eMBB: Enhanced Mobile Broadband
  - ✓ eMBB：增强移动带宽
  - Wireless communication and Switching on Layer 2
  - ✓ 在第2层的无线通信和交换



Communication between Nacelle and the Hub in wind turbine
风力发电机中机舱和轮毂之间的通信

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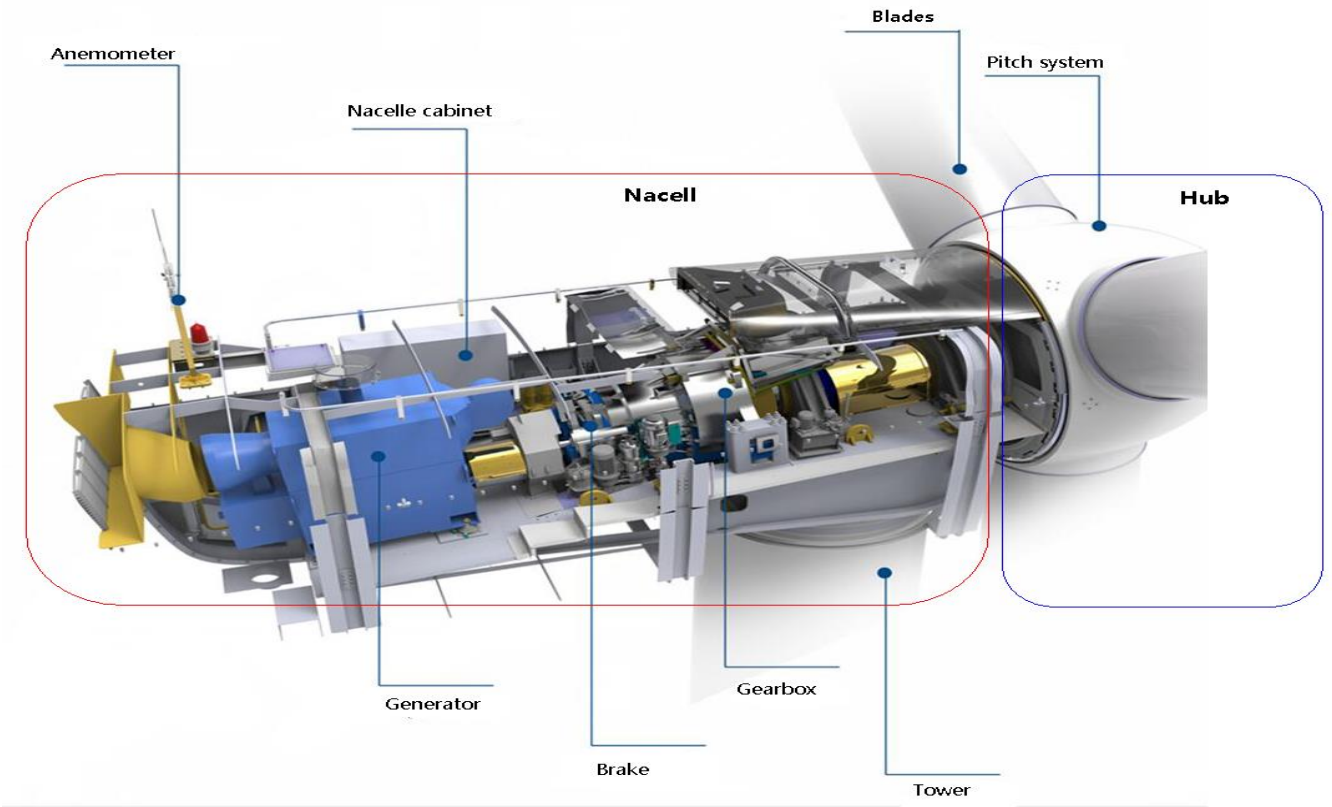
Background：Because the hub is a rotating component, communication between the hub and the nacelle has to be achieved through slip rings. Slip ring is expensive and costly to maintain. A problem with the slip ring can easily cause a communication interruption and turbine stop.

背景：由于轮毂为旋转部件，轮毂和机舱之间的通讯需要通过滑环实现。滑环价格昂贵，维护成本高。滑环出现问题容易造成通讯中断停机。



Communication between Nacelle and the Hub in wind turbine
风力发电机中机舱和轮毂之间的通信

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Application requirements 应用需求：

- Pitch control, 10~20ms communication cycle time 变桨实时控制，10~20ms通讯周期
  - Low Latency 低延时
  - High Reliability 高可靠
- File transfer：software update and log file download 文件传输：软件更新和日志文件下载
- Sensor data acquisition for blades condition monitoring 桨叶状态监测的传感数据采集
  - Bandwidth:100Kbps-10Mbps 带宽需求：100Kbps-10Mbps

Customer focus：

- 5G Base station deployment 5G基站的布置
- The influence of the metal between Hub and Nacelle 轮毂与机舱间金属部件的影响
- Low Costs 低成本

AGV vehicle remote control & monitoring in Port
港口AGV车辆的远程控制和监测

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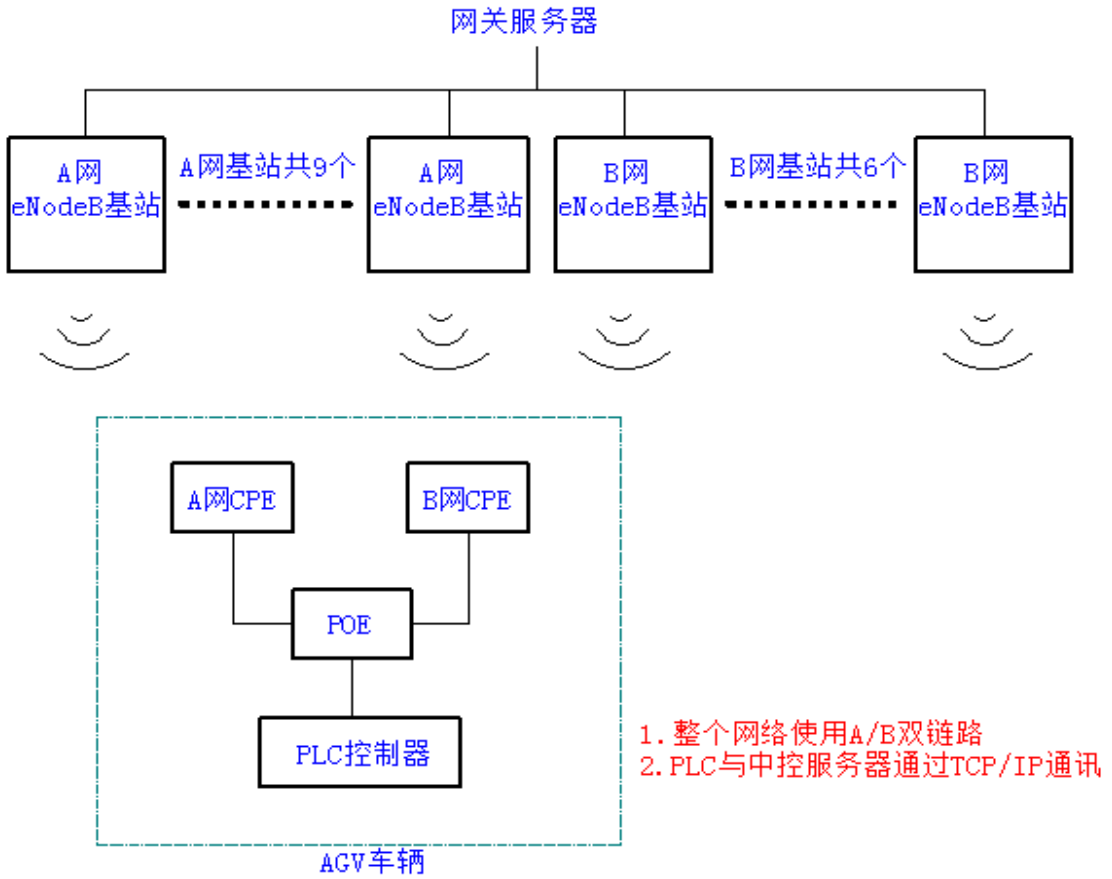
Background: Remote monitoring of AGV vehicle for port container handling

- Establishing private network by unlicensed band equipment of LTE-U
- Central Control → LTE Core Controller → Base Station → CPE(Customer Premises Equipment) → POE(Industrial switch) → Vehicle controller

背景：港口集装箱装卸AGV车辆的远程监控

- 通过LTE-U未授权频带建立私有网络
- 中央控制器→LTE核心控制器→基站→CPE（客户终端设备）→POE（工业交换机）→车辆控制器



Disadvantage of current solution当前方案的弱点:

- Reliability, low latency, and large bandwidth cannot be satisfied at the same time. At present, large bandwidth and some low latency are sacrificed to ensure reliability.

✓ 可靠性、低时延和大带宽不能同时满足，目前，牺牲了大带宽和部分低延迟以保障可靠性

- Video transmission can not be well supported by 4G.

✓ 4G不能很好地支持视频传输

AGV vehicle remote control & monitoring in Port
港口AGV车辆的远程控制和监测

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Application requirements 应用需求 ：

- Central Control issued phased position instructions 中央控制器发布分步的位置指令
- AGV vehicle return real-time position AGV车辆返回实时位置
- Video is required for remote control of cranes 为了远程控制吊车而需要视频
- Security, reliability, low latency, and large bandwidth can be achieved at the same time by means of The concept of Network Slicing

✓ 安全、可靠、低时延和大带宽可以由网络切片的概念同时满足

Customer focus：

- Cyber security is very important if Public 5G network can be used in this case

✓ 如果使用公共5G网络时信息安全尤为重要

- If public 5G network used, compared to the current private network 4G plan, it will save a lot of infrastructure wireless equipment and follow-up maintenance costs.

✓ 如果使用公共5G网络，相比于现在的4G私有网络，将节省大量的无线通信基础设施和后续的维护成本

Mobile control panel in CNC machine
数控机床移动控制面板

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Background：Manual Pulse Generator (MPG) is a hand-held terminal used for CNC machine tool adjustment and preparation. But most of the MPGs are with cable, which is easy to break and inconvenient. So wireless MPG will be meaningful very much, but also some problem to be overcomed.

背景：手动脉冲发生器(MPG)是机床调整和准备时常用的手持终端。大部分MPG都是有线的，使用不便，而且易于损坏。采用无线通信将非常有意义。

Wireless Communication in CNC machine

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Application requirements 应用需求：

- Always ready to use 随时可用
- Isochronous real-time communication, but relatively long cycle time (50-100ms)
- ✓ 等时实时通信，但是相对较长的周期时间(50-100ms)
- Other operation functions, such as, START, STOP, JOG, etc.

Customer focus：

- Communication reliability 通信的可靠性
- Low latency 低时延
- Functional safety 功能安全

Thank YOU ！