



IHS Markit™

Sensors for IoT: How big is the market going to be?

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Outline

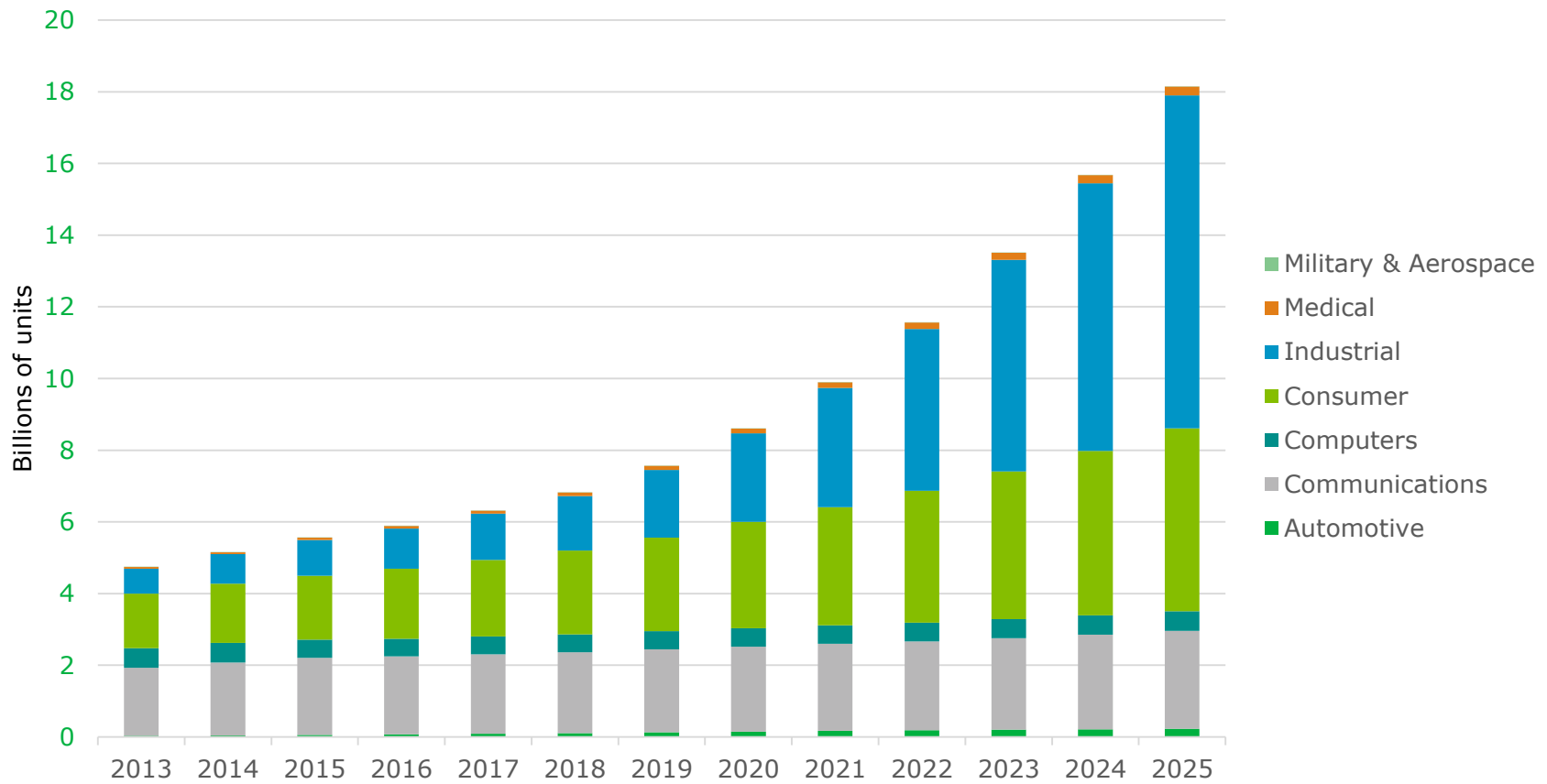
- How big is the market
- Smart homes and smart buildings
- Smart manufacturing
- Sensors in the IoT ecosystem

How big is the market for sensors for IoT?

What is the additional market opportunity for sensors created by IoT?

10s of billions of connected devices

Shipment of Internet Connectable Devices



Source: IHS Markit - IoT Devices and Connectivity Intelligence Service - Q2 2016

Scope of sensors for IoT research

Application focus

- Volume applications
 - > Smartphones and tablets
 - > Wearables
 - > Smart homes
 - > Domestic, service robots
 - > Drones
 - > White goods, appliances
 - > Automotive
 - > Other consumer
- Industrial / Infrastructure applications
 - > Automation and process control
 - > Smart grid
 - > Mobile machinery (tractors, cranes...)
 - > Asset tracking
 - > Smart buildings
 - > Smart cities
 - > Medical/healthcare
 - > Agriculture, environment
 - > Seismic sensing, civil engineering
 - > Military, homeland security
 - > Other industrial

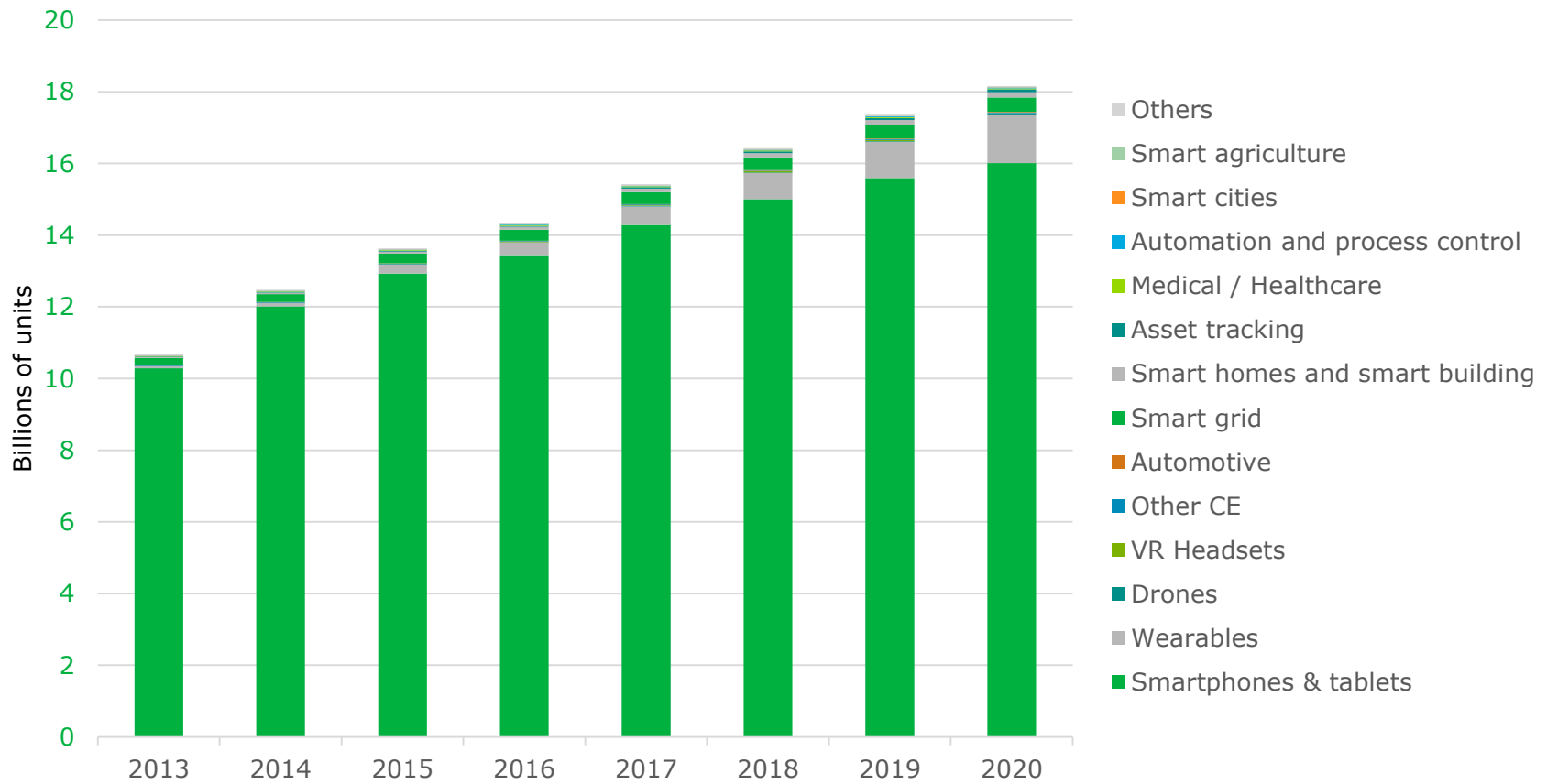
Scope of sensors for IoT research

Component focus: silicon and non-silicon

- Inertial/vibration sensors
 - > Accelerometers
 - > Gyroscopes
 - > Magnetometers
 - > IMUs (all of the above in one module)
 - > Vibration
- Environment sensors
 - > Temperature
 - > Gas
 - > Chemical
 - > Particulate (PM2.5 etc)
 - > Light
 - > Humidity
- Pressure / Flow
 - > Pressure Sensors
 - > Flow sensors
- Presence/motion sensors
 - > Infrared, magnetic, ultrasonic, capacitive...
- Position/torque/rotation speed/commutation
- Current sensors
- Imaging
 - > CMOS/CCD
 - > Infrared imaging
- Microphones
 - > MEMS
 - > ECM
- Silicon Energy scavengers

Sensor for IoT: how big is the market?

Shipment of sensors for IoT applications (preliminary estimate)



Source: IHS Markit – MEMS & Sensors for IoT report 2016 (preliminary)

Smart homes and smart buildings

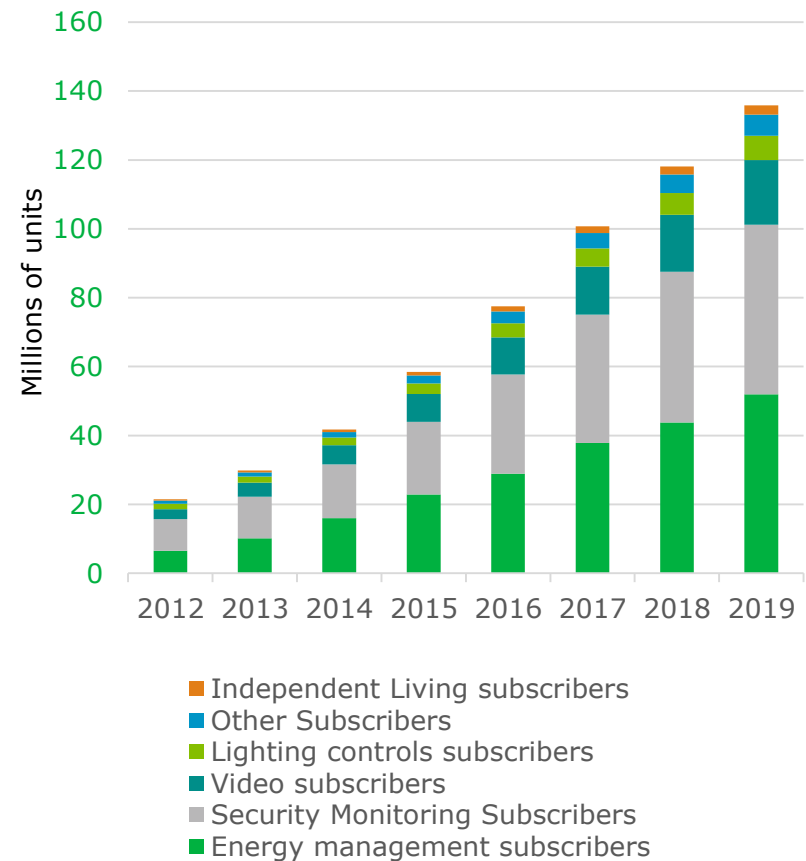
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Sensors for smart homes

Service subscription business

- Especially in North America with NEST, ADT, AT&T, Vivint, Comcast...
- Services driving adoption of services are energy management, security, lighting control
- Top sensors in volumes: pyroelectric motion detector, temperature, magnetic switches, light sensors

Sensor shipment for smart homes by subscription service

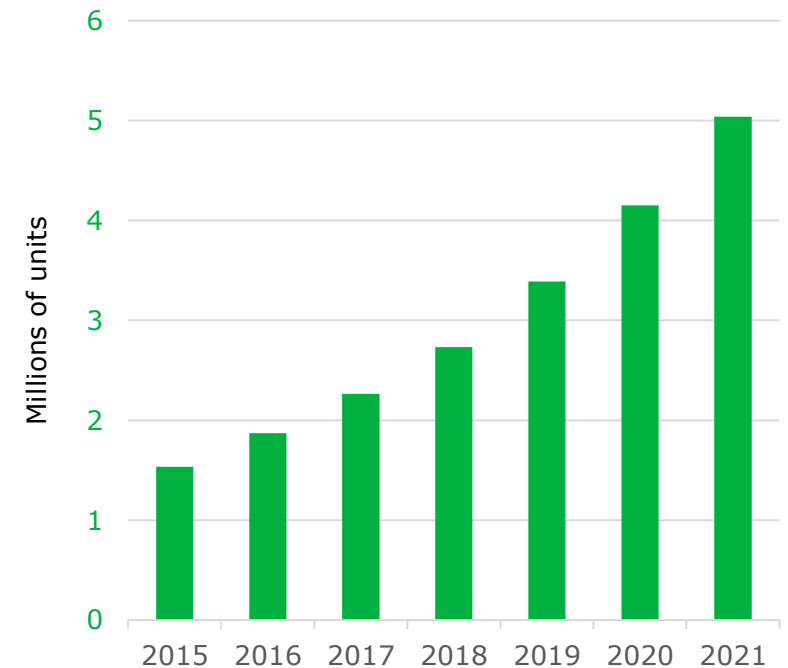


New applications for smart homes

Air purifiers & air quality monitors

- Demand for air purifiers is skyrocketing in China and India. Japan is 3rd market
 - > E.g. from Sharp, Eureka Forbes
 - > Includes particle sensors, gas sensors (VOC, some CO2), humidity sensors, light sensors...
- Table top air quality monitors also include temperature sensor
 - > Connected to smartphones
 - > Offered by start-ups such as Netatmo, Bitfinder, VisualAir...

Sensor shipment for connected Air Purifiers and Tabletop Air quality Monitors



■ Sensors for Air Purifiers and Air Monitors in smart homes

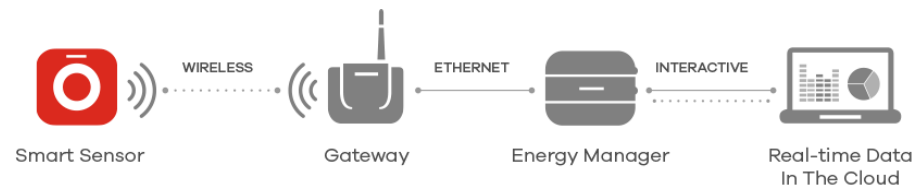
Smart building: more sensors through lighting

Example Enlighted Inc.

- Lighting and energy cost management for commercial buildings
- Enlighted subscription and install sensors, gateway and energy managers
- Savings on energy bill
 - > Company 1: 11 Buildings (550K Sq. ft): \$170k savings/year
 - > Company 2: 201 Buildings (20M Sq.ft): \$8M saving / year!!!
- Beyond energy saving:
 - > Monitoring building usage
 - > New sensors to come e.g. CO2 sensors for productivity



Smart sensor , deployed with LED light fixture. Includes pyrodetector (motion and temperature sensing) and Light sensor (source Enlighted)

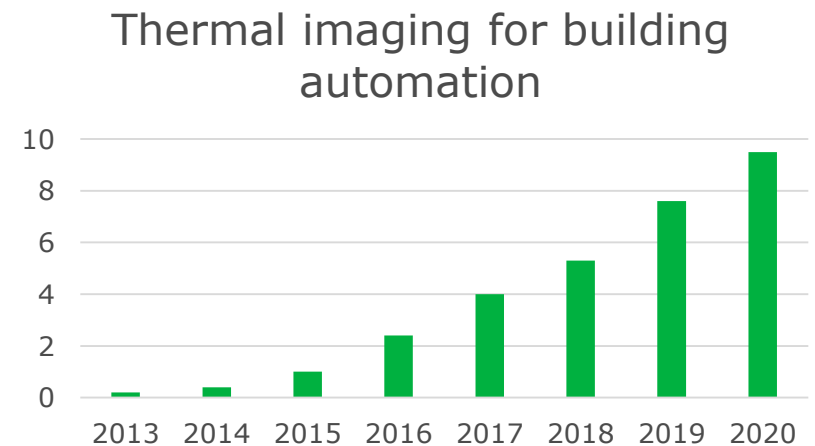


Infrared imaging takes off for smart buildings

- HVAC Control (cost saving and comfort), Lighting control, People counting
- Connected to the cloud (e.g. Panasonic)
- Thermopile arrays emerged since 2013
 - > Panasonic, Heimann, Omron...
- Microbolometers from 2017
 - > FLIR, ULIS...



Grid-EYE thermopile array, 8x8 (source Panasonic)



Source: IHS Markit – MEMS & Sensors for IoT report 2016 (preliminary)

Sensors in smart buildings

Climate control is major driver

- Demand for established sensors fro HVAC increases fast
 - > Temperature
 - > Pressure sensors e.g. from Dunan, Acuity...
 - > Pyrodetector: Excellitas, Nicera...
- Also stimulates demand for new sensors related to HVAC / lighting control
 - > Ambient Light
 - > Infrared imaging
 - > CO2 (NdIR sensors, not MEMS)
 - > MEMS Vibration sensors (condition monitoring)
 - > MEMS valves
- Less traction than expected for:
 - > Microphones (except for Audio feature cameras). Privacy issue.

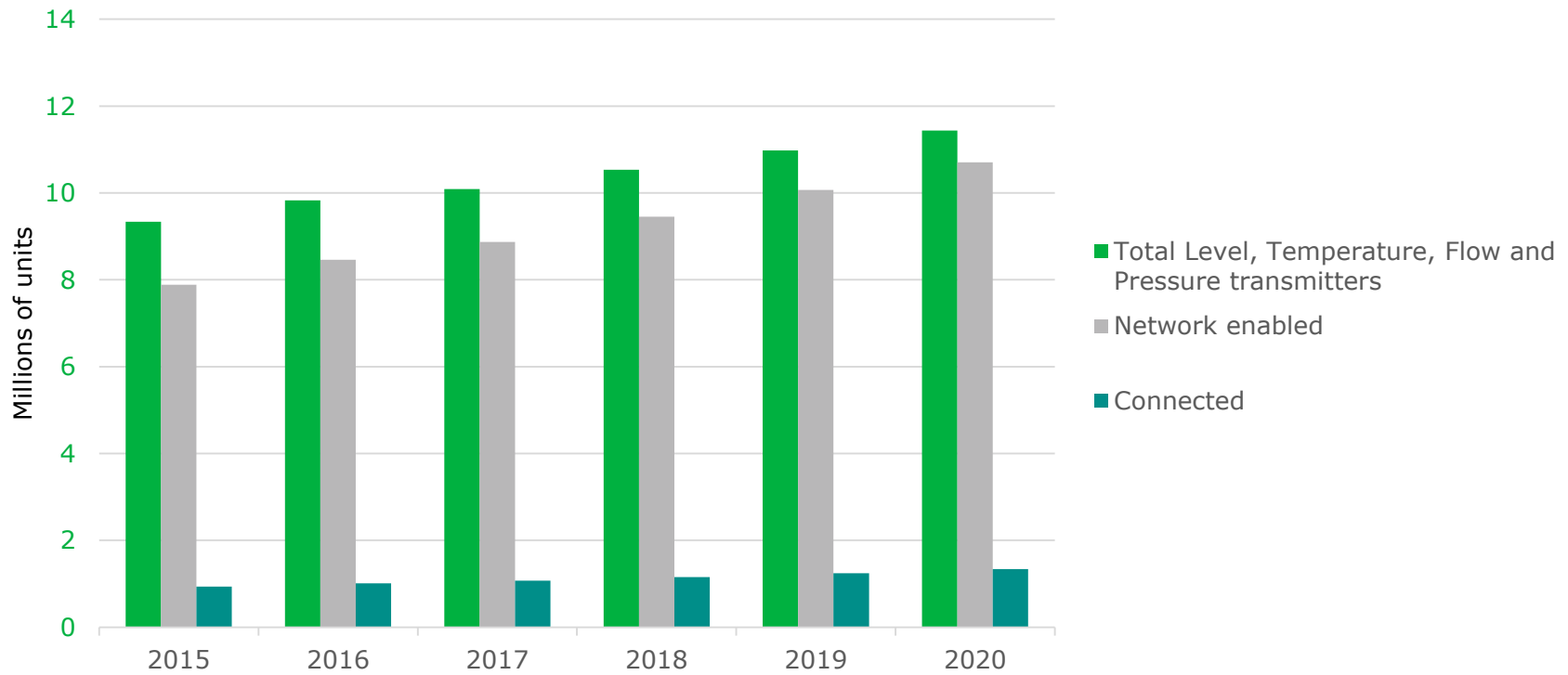
Sensors for smart manufacturing

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Transmitters for process control

Majority are network enabled, small percentage are connected

Shipment of Transmitters for Industrial Process Control
(pressure, temperature, flow, level)



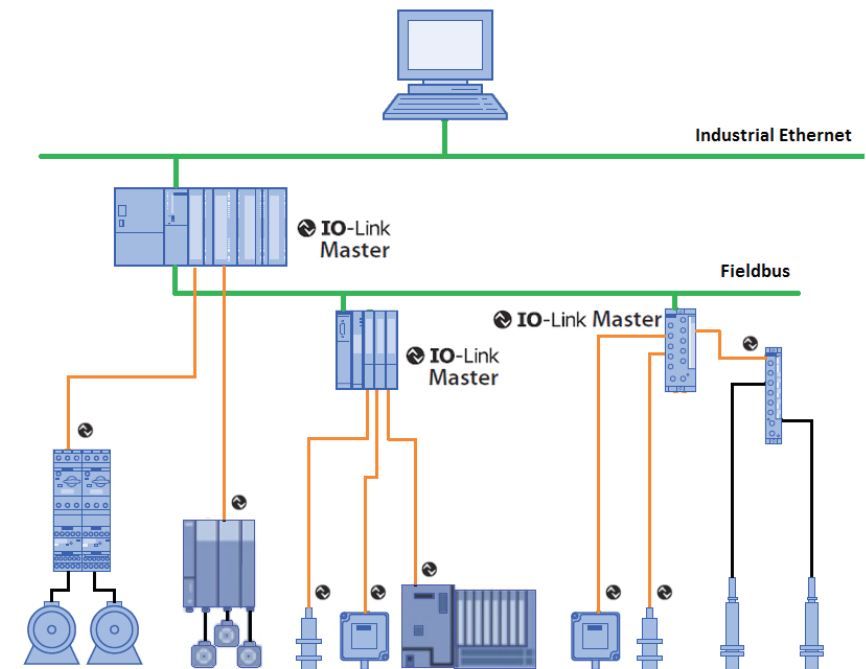
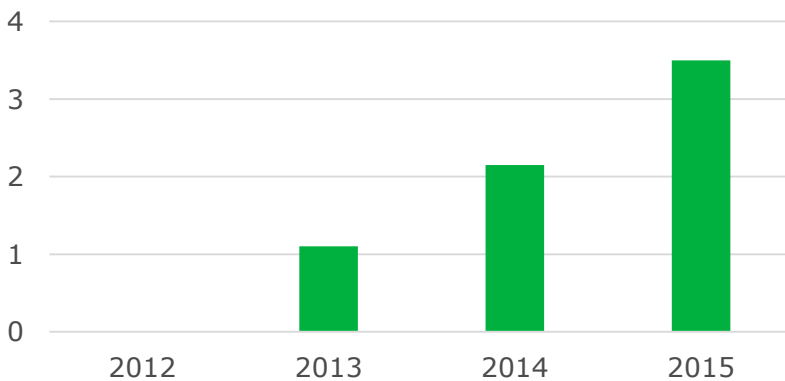
Source: IHS Markit – Industrial Communications Report 2016

Emergence of standard communication protocol for sensors and actuators in discrete automation

IO link

- Started shipping in 2013. Now majority of new sensor design at Sick, Rockwell etc are IO Link enabled
- Simplifies linking of sensors to the cloud in automation.
- No significant impact on traditional automation sensor shipment

Installed of IO-Link nodes



Example of system architecture with IO-Link (source IO-Link)

Vibration sensing for predictive maintenance

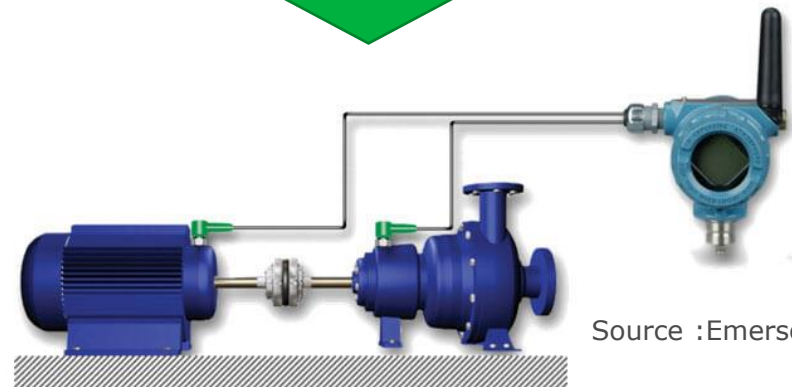
From manual to on-line monitoring

- Monitoring of critical rotating equipment such as pumps, motors, compressors
- Wireless vibration transmitters appeared around 2010
- Acceptance raises in 2016. Better acknowledgment of ROI
- Expensive though
 - > Piezo-ceramic vibration sensors: \$100-\$400
 - > Wireless vibration transmitter: \$5000-\$6000
- Still small market (10ks)

Manual monitoring of critical assets, typically once a month



Source :AZIMA



Source :Emerson

On-line monitoring, wired or wireless.
Several measurement per day.

Making vibration sensing mainstream

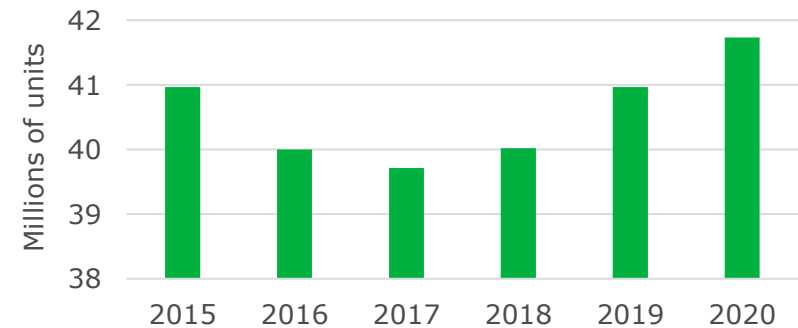
ABB's smart sensor

- ABB launches wireless vibration sensors with bluetooth connection for Low Voltage motors end 2016
- Only 50€ in volume, probably MEMS inside
- Makes vibration sensing affordable for lighter industrial assets.
- Low voltage motors cost typically \$250 to \$400.
- For new motors and for retrofit market
- ABB claims TAM of 300 million motors

Wireless vibration sensor module for 50€ (photo IHS, Hannover Fair)



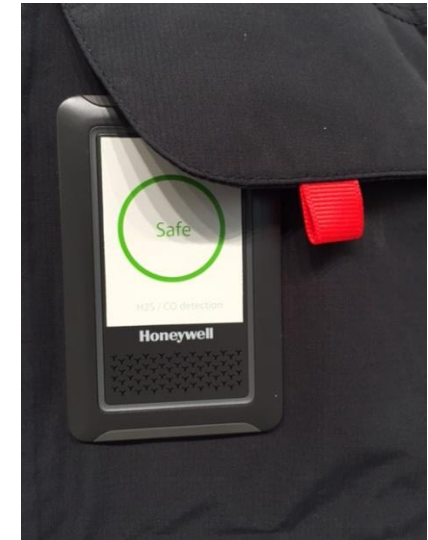
Low voltage industrial motors shipments



MEMS for the connected worker

- Strong push by Honeywell, Intel, Siemens etc
- Drivers are safety and productivity
- Look for small and low power sensors
- Opportunity for MEMS:
 - > Gas sensors for air quality
 - > Accelerometers and IMUs for location based service, step count, workflow navigation, hand-free navigation, impact sensing
 - > Microphones for voice control
- Volume shipment in 2017

H2S/CO detectors by Honeywell using MEMS gas detectors will start shipping in Q4 2016

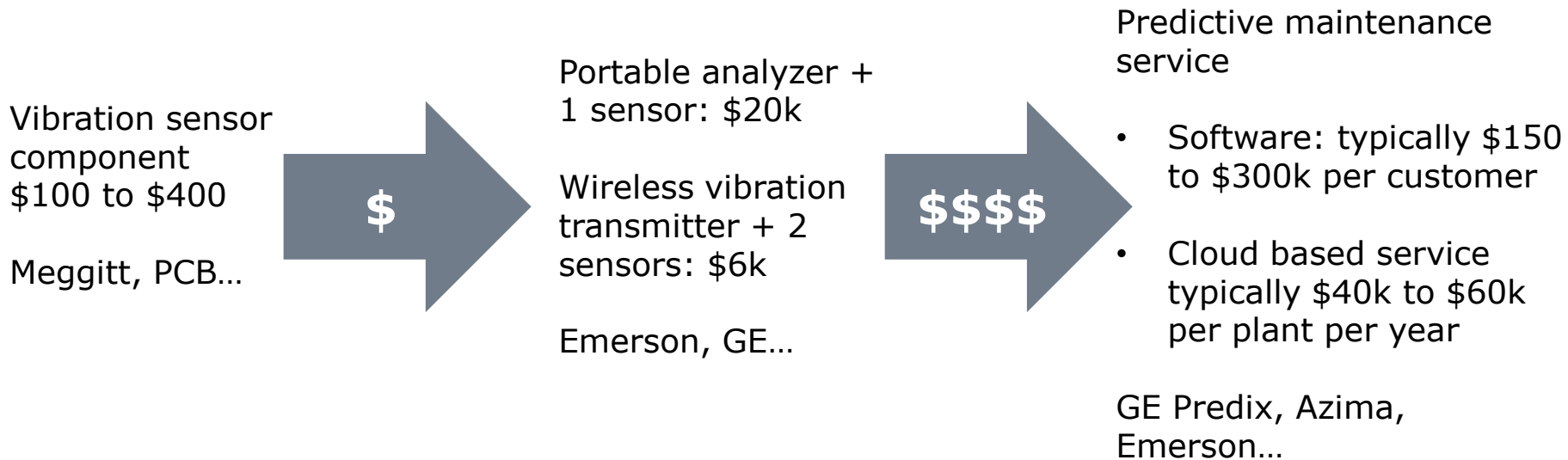


Source IHS photo, Hannover Fair 2016

Sensors in the IoT ecosystem

Sensors enable new services and business models

Example vibration sensing for predictive maintenance



Shift of business from selling hardware to selling service

- GE not selling engines for aircrafts but selling uptime
- Bearing companies SKF and FAG adding sensors into bearings and selling services
- ABB selling not only motors but energy savings and uptime

Sensors are a small part of a complex ecosystem

Example: supply chain for IOT and smart manufacturing



Example technologies and services

<ul style="list-style-type: none"> • Micro controllers • Connectors • Wireless ICs • Sensors 	<ul style="list-style-type: none"> • Processing machines • Packaging machines • Material Handling • Robotics 	<ul style="list-style-type: none"> • PLCs • Operator terminals • Remote I/O • IPC's • Motion control products 	<ul style="list-style-type: none"> • Servers • Routers • Switches • Computers 	<ul style="list-style-type: none"> • Networking • Industrial protocols • 5G • LoRaWAN 	<ul style="list-style-type: none"> • IP protection • Equipment downtime prevention • Regulation compliance • Worker safety 	<ul style="list-style-type: none"> • Cloud • Connectivity management • Data management • Device management • Application enablement 	<ul style="list-style-type: none"> • PLM • MES/MOM • ERP • SCADA 	<ul style="list-style-type: none"> • Technology expertise • IT and OT collaboration • Change management 	<ul style="list-style-type: none"> • Remote Monitoring • Predictive maintenance • Plant visualisation • Design and simulations tools 	<ul style="list-style-type: none"> • Enables new business models (seller of XaaS) • Enables new operations (customer of XaaS)
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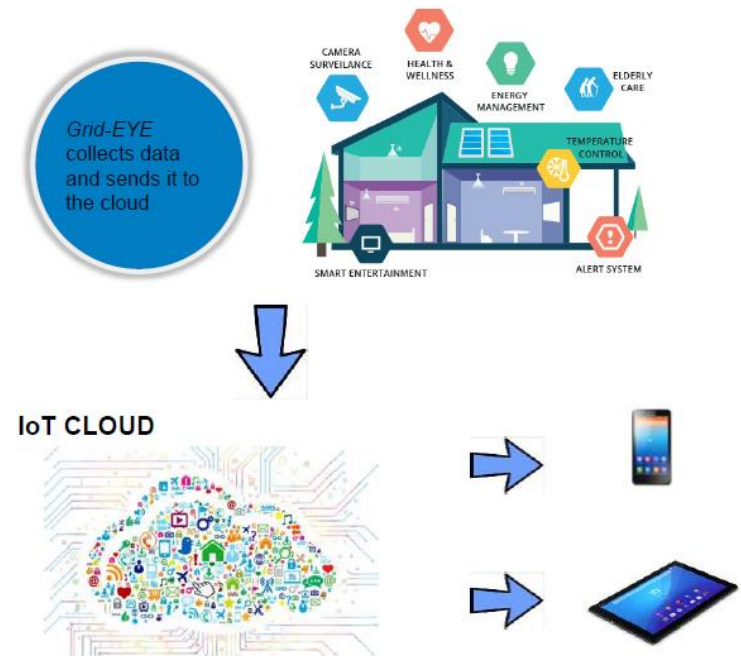
Example Stakeholders

<ul style="list-style-type: none"> • Intel • Qualcomm • Infineon • Toshiba • NXP • Balluff • SICK 	<ul style="list-style-type: none"> • Bosch • Packaging Tech • ProMach • ITW • Tetra Laval • Krones • FANUC • KUKA 	<ul style="list-style-type: none"> • GE • Rockwell • Siemens • Schneider Electric • Emerson • Mitsubishi Electric 	<ul style="list-style-type: none"> • Cisco • Belden • Dell • HP 	<ul style="list-style-type: none"> • Vodafone • AT&T • Huawei • Ericsson • Orange 	<ul style="list-style-type: none"> • Symantec • McAfee • Lockheed-Martin 	<ul style="list-style-type: none"> • Microsoft • IBM • SAP • GE • Siemens • Bosch 	<ul style="list-style-type: none"> • Oracle • Dassault • PTC • SAP • Honeywell 	<ul style="list-style-type: none"> • Accenture • Capgemini • Maverick Technologies • PwC • Tata?? • M+W Automation 	<ul style="list-style-type: none"> • IBM • GE • Siemens • PTC 	<ul style="list-style-type: none"> • Coca-Cola • BMW • Foxconn • Samsung • Shell • BASF
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Source: IHS Markit – Smart Manufacturing Intelligent Service 2016

How can sensor makers accelerate implementation of sensor based solution and retain value?

- Vertically integrated companies seem to be faster
 - > Dunan – leading Chinese HVAC system manufacturer. Faster growing MEMS pressure sensor for HVAC
 - > Panasonic: fastest growing supplier of infrared imaging for smart building
- Cooperations with Intel, IBM...
- Sensor and semiconductor supply solution with sensor + power management + MCU + connectivity IC
- Sensor component makers must offer software algorithms to simplify data analytics
 - > Leverage experience from consumer e.g. pedestrian dead reckoning for connected worker
 - > Or significant investment e.g. for vibration sensing



Source: Panasonic

Some smaller MEMS companies climb-up the value chain

- From component maker to full system maker
 - > Siargo: offers full smart flow meters as opposed to only the MEMS flow sensor
 - > Micropelt: focus on batteryless radiator valves for smart buildings rather than only MEMS energy harvesters
 - > Debiotech: from MEMS pump to entire system with patch pump
 - Massive investment since 2009 to develop android command for connected pump and address related security issues



Source: Siargo (upper left) and Micropelt (upper right)



Source: Debiotech

Conclusion

- Sensors for IoT. Not a trillion additional sensors. But a number of opportunities in the millions or 10s of millions of units.
- IoT is often about re-using existing sensor. Example automotive
 - > Remote diagnostic with On-Star re-use signal from existing sensors
 - > Also insurance black boxes re-use existing sensors in majority of cases
- Volume opportunities for sensors when clear return on investment e.g. sensors for smart buildings with saving on energy and lighting bills
- Opportunities for MEMS for „indirect use“ e.g. accelerometers for power management in battery operated connected devices. 10s of millions of units.
- Sensors are small part of complex ecosystem. Need cooperations.