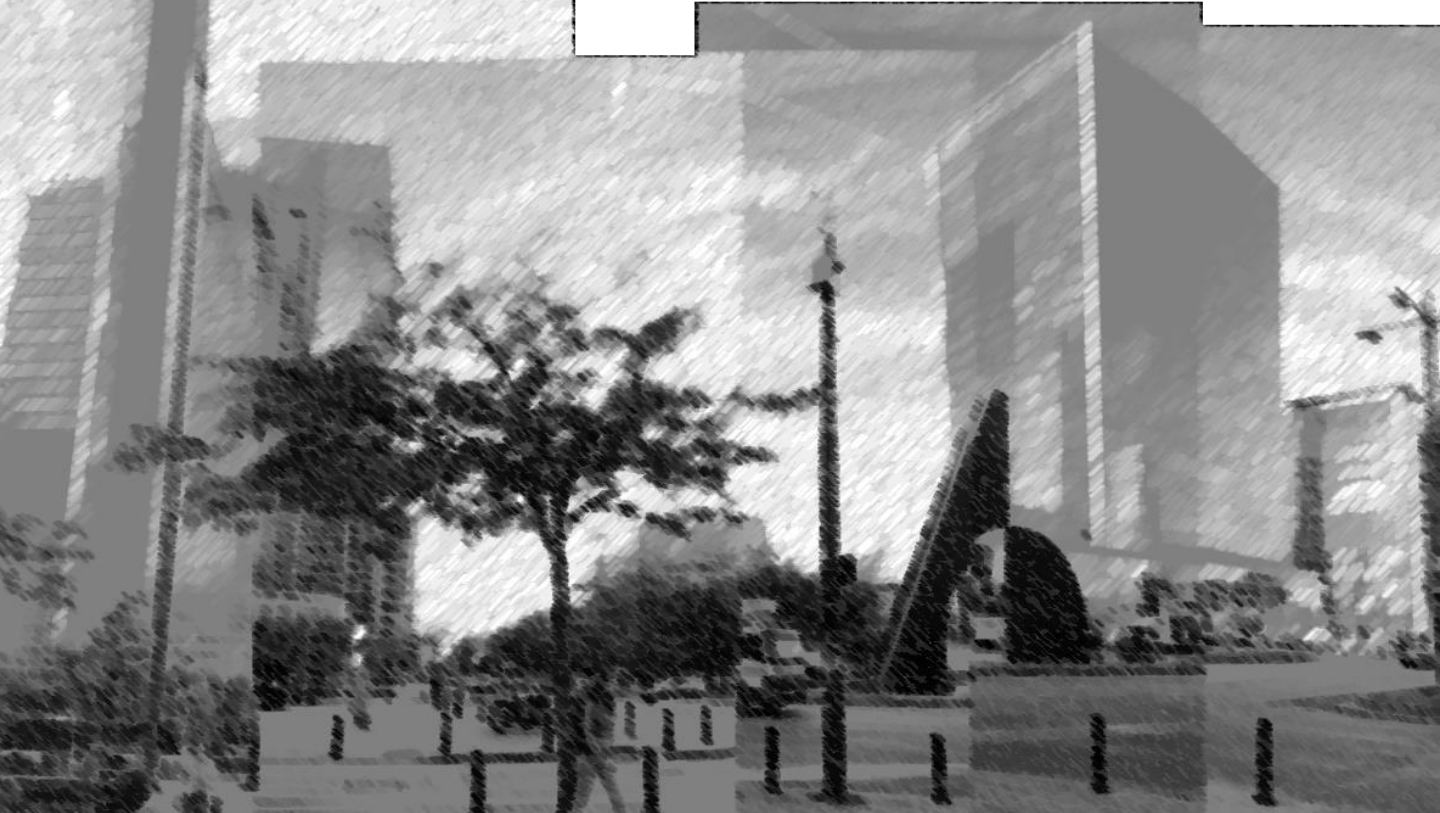


# Overview LP-WAN

IoTBE 17/09/2015 - Brussels



# Who am I?

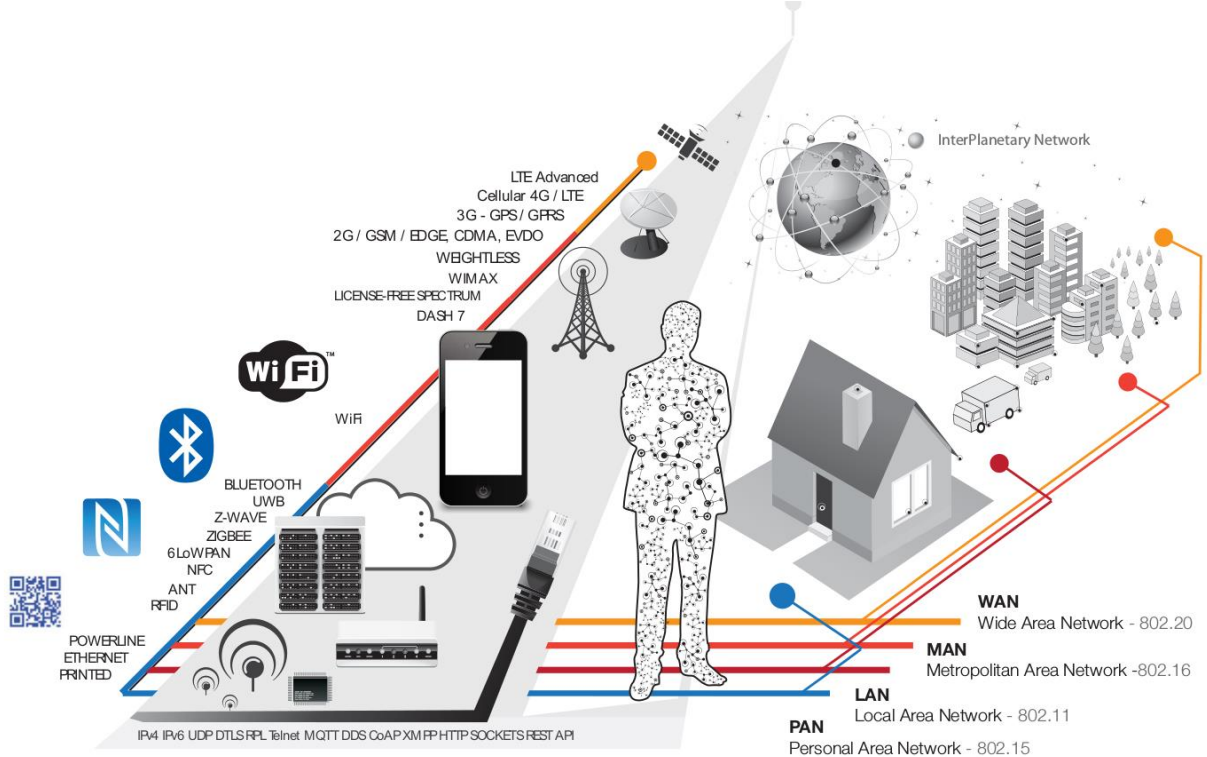
Maarten Weyn

- Prof @ UAntwerpen/iMinds
- MOSAIC Research Group
- Low Power Communication and Localization
- Embedded x communication x low power
  
- 2 Spinoff Companies (localization & tracking)
  
- Courses:
  - Mobile Communication
  - Communication Systems
  - Ambient Intelligence (Low Power)

# Wide Area Network

- BAN < PAN < LAN < CAN < MAN < WAN
- “Network spanning regions, countries or even the world”
- ≠ Long Range Communication

# Wide Area Network



Courtesy of Postscapes & Harbor Research.

# Low Power

≠ Low Energy

$$E = P * t$$

# Low Power Wide Area Network

- Long Range Network
- Low Energy Consumption
- Low Cost
- Focus on battery operated devices
- Very low speed
- License free frequencies

Frequency	Duty cycle	ERP
863-865 MHz	100% (wireless audio)	10 mW
863.0 – 865.6 MHz	0.1% or LBT+AFA	25 mW
865.0 – 868.0 MHz	1% or LBT+AFA	25 mW
868.0 – 868.6 MHz	1% or LBT+AFA	25 mW
868.7 – 869.2 MHz	0.1% or LBT+AFA	25 mW
869.4 – 869.65 MHz	10% or LBT+AFA, 25 kHz channel spacing	500 mW
	10% or LBT+AFA	25 mW
869.7 – 870.0 MHz	100% (voice communication)	5 mW
	1% or LBT+AFA	25 mW

# Technologies

Non exhaustive list:

- SigFox
- LoRaWAN ≠ LoRA
- LTE-M
- Amber Wireless
- Nwave (Weightless-N)
- Platanus (M2COMM – Weightless - P)
- Telensa (Senaptic)
- Ingenu Networks (former OnRamp 2.4 Ghz, 10Kbit/s, RPMA)
- Weightless (W: whitespace, N: narrowband, P)
- DASH7 Alliance Protocol

# Example Comparison

	LoRa	NWave	OnRamp	Platanus	SIGFOX	Telensa	Weightless -N	Weightless -P	Amber Wireless	M2M Spectrum
Range (km) (Caveat)	15-45 flat; 15-22 suburban; 3-8 urban	10	4 (but claims 25x competition)	Several hundred meters	50 rural; 10 urban	Up to 8	5+	2+ urban	Up to 20	
Band (MHz)	Spread; varies by region	Sub-GHz	2.4 GHz	Sub-GHz	868;902	868/915 470 (China)	Sub-GHz	Sub-GHz	434, 868, 2.4 GHz	800/900
ISM?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Symmetric up/down?	No	No	No (4:1)	No	No	Yes	Uplink only	Not yet determined		
Data rate (Caveat)	0.3-50 kbps (adaptive)	100 bps	8 bps – 8 kbps	500 kbps	100 bps	Low	30 kbps-100 kbps	Up to 100 kbps (adaptive)	Up to 500 kbps**	
Max nodes (Caveat)	Depends; 200K-300K/hub	Million/base	“10s of 1000s”	50,000	Millions/hub	150,000/Server (moving to 500,000)	No real claim (due to “it depends”)	32767 NWs, 65535 hubs each, 16M edge device per NW	255 networks of 255 nodes	
OTA upgrades?	Yes	Yes	Yes	Yes	Doubtful	Yes	No	Yes		
Handoff?	No; no node/hub association	No; it’s being considered	Yes	Yes	Doubtful	Yes	Yes	Yes		
Operational model	Public or private (expect 80% public)	Public or private	Public or private	Public or private	Public	Public	Public or private	Public or private		Public
Standard status (if any)	No	Weightless-N	IEEE; in process	Weightless-P	No	No (perhaps in future)	Yes	In process; spec later this yr		

Source: Bryon Moyern: A Survey of Longer-Range IoT Wireless Protocols



Comparison of Low-Power WAN Alternatives

Name of Standard	Weightless			SigFox	LoRaWAN	LTE-Cat M	IEEE P802.11ah (low power WiFi)	Dash7 Alliance Protocol 1.0	Ingenu RPMA	nWave
	-W	-N	-P							
Frequency Band	TV whitespace (400-800 MHz)	Sub-GHz ISM	Sub-GHz ISM	868 MHz/902 MHz ISM	433/868/780/915 MHz ISM	Cellular	License-exempt bands below 1 GHz, excluding the TV White Spaces	433, 868, 915 MHz ISM/SRD	2.4 GHz ISM	Sub-GHz ISM
Channel Width	5MHz	Ultra narrow band (200Hz)	12.5 kHz	Ultra narrow band	EU: 8x125kHz, US 64x125kHz/8x125kHz, Modulation: Chirp Spread Spectrum	1.4MHz	1/2/4/8/16 MHz	25 KHz or 200 KHz	1 MHz (40 channels available)	Ultra narrow band
Range	5km (urban)	3km (urban)	2km (urban)	30-50km (rural), 3-10km (urban), 1000km LoS	2-5k (urban), 15k (rural)	2.5- 5km	Up to 1Km (outdoor)	0 – 5 km	>500 km LoS	10km (urban), 20-30km (rural)
End Node Transmit Power	17 dBm	17 dBm	17 dBm	10µW to 100 mW	EU:<+14dBm, US:<+27dBm	100 mW	Dependent on Regional Regulations (from 1 mW to 1 W)	Depending on FCC/ETSI regulations	to 20 dBm	25-100 mW
Packet Size	10 byte min.	Up to 20 bytes	10 byte min.	12 bytes	Defined by User	~100 -~1000 bytes typical	Up to 7,991 Bytes (w/o Aggregation), up to 65,535 Bytes (with Aggregation)	256 bytes max / packet	Flexible (6 bytes to 10 kbytes)	12 byte header, 2-20 byte payload
Uplink Data Rate	1 kbps to 10 Mbps	100bps	200 bps to 100 kbps	100 bps to 140 messages/day	EU: 300 bps to 50 kbps, US:900-100kbps	~200kbps	150 Kbps ~ 346.666 Mbps	9.6 kb/s, 55.55 kbps or 166.667 kb/s	AP aggregates to 624 kbps per Sector (Assumes 8 channel Access Point)	100 bps
Downlink Data Rate	1 kbps to 10 Mbps	No downlink	200 bps to 100 kbps	Max 4 messages of 8 bytes/day	EU: 300 bps to 50 kbps, US:900-100kbps	~200kbps	150 Kbps ~ 346.666 Mbps	9.6 kb/s, 55.55 kbps or 166.667 kb/s	AP aggregates to 156 kbps per Sector (Assumes 8 channel Access Point)	--
Devices per Access Point	Unlimited	Unlimited	Unlimited	1M	Uplink:>1M, Downlink:<100k	20k+	8191	NA (connectionless communication)	Up to 384,000 per sector	1M
Topology	Star	Star	Star	Star	Star on Star	Star	Star, Tree	Node-to-node, Star, Tree	Typically Star. Tree supported with an RPMA extender	Star
End node roaming allowed	Yes	Yes	Yes	Yes	Yes	Yes	Allowed by other IEEE 802.11 amendments (e.g., IEEE 802.11r)	Yes	Yes	Yes
Governing Body	<a href="#">Weightless SIG</a>			<a href="#">Sigfox</a>	<a href="#">LoRa Alliance</a>	<a href="#">3GPP</a>	IEEE 802.11 working group	<a href="#">Dash7 Alliance</a>	<a href="#">Ingenu (formerly OnRamp)</a>	<a href="#">Weightless SIG</a>
Status	Limited deployment awaiting spectrum availability	Deployment beginning	Standard in development. Scheduled release 4Q 2015	In deployment	Spec released June 2015, in deployment	Release 13 expected 2016	Targeting 2016 release	Released May 2015	In Deployment	In Deployment

# LoRaWAN

# SigFox



# SigFox



- Ultra Narrow Band
- SDR based gateways
- International network with national SNO (Sigfox Network Operator)
- Belgium -> Engie M2M
- Silicon Agnostic -> cheaper HW
- Uplink
  - 12 bytes payload, total transmission  $\pm 6$  sec
  - Max transmission every  $\pm 12$  min (140/day)
  - 100 bps, BDPSK
- Downlink
  - 8 byte payload
  - Requested with upload
  - Guaranteed 4/day

# LoRaWAN



- = alliance
- = LoRa (PHY) + higher network layers
- Using proprietary Semtech hardware
- Based on traditional network operators → Proximus
  
- 125 Khz Spread Spectrum
- SF12 → SF6
- Class A, B, C
  - A: Bi-directional end-devices
  - B: “ + scheduled receive slots
  - C: “ + maximal receive slots
- ACK Possible
- 863-870 MHz
  - 3 125 KHz data channels
  - 6 125 KHz Join Request channels
- DR0-5 → SF 12-7 → 250 bps – 5470 bps  
→ 51-242 bytes max app payload

# Low Power Communication



**Frequency**  
**Data rate**  
**Range**  
**Standardization**  
**Power Consumption**  
**Integration capabilities**

# Frequency



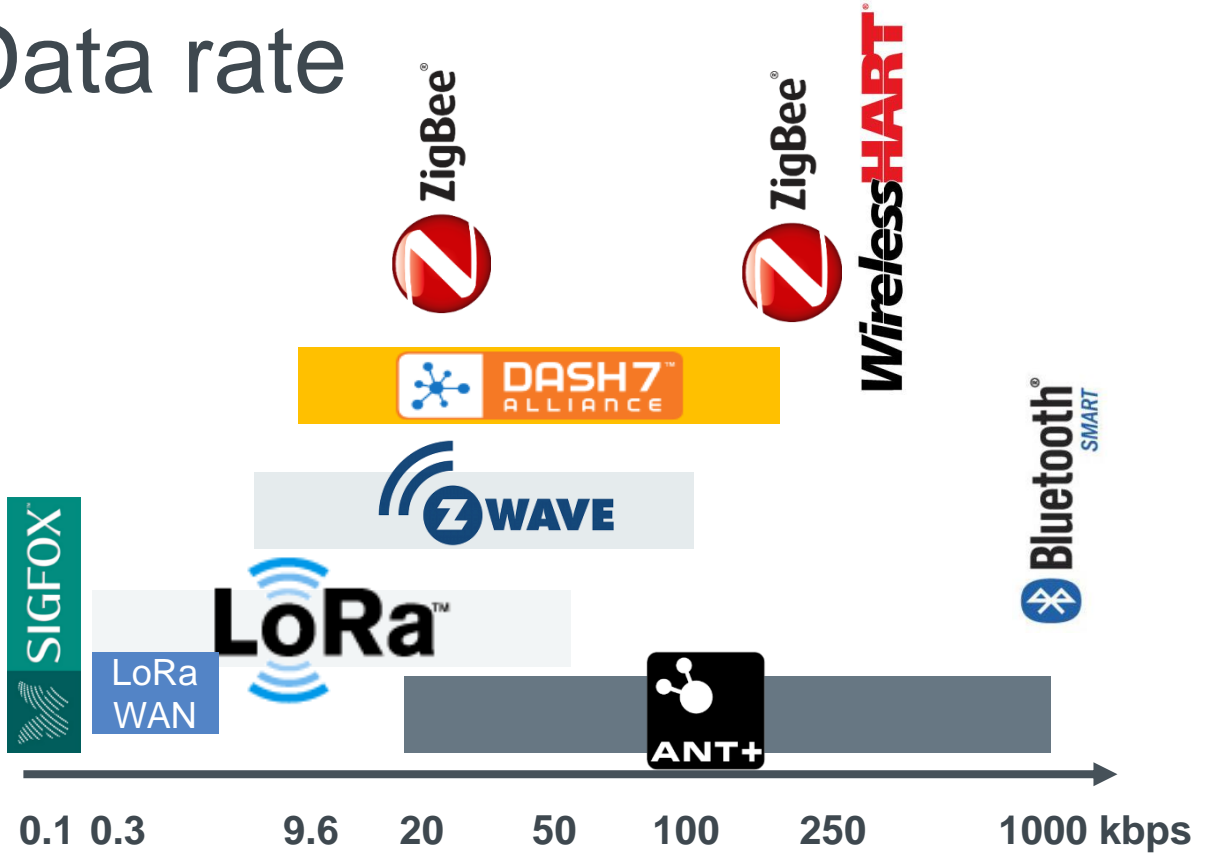
433

868/915

2400 MHz



# Data rate



# Range



**WirelessHART**



30

100

5 km

50km

Low-Range

Long-Range

Mid-Range



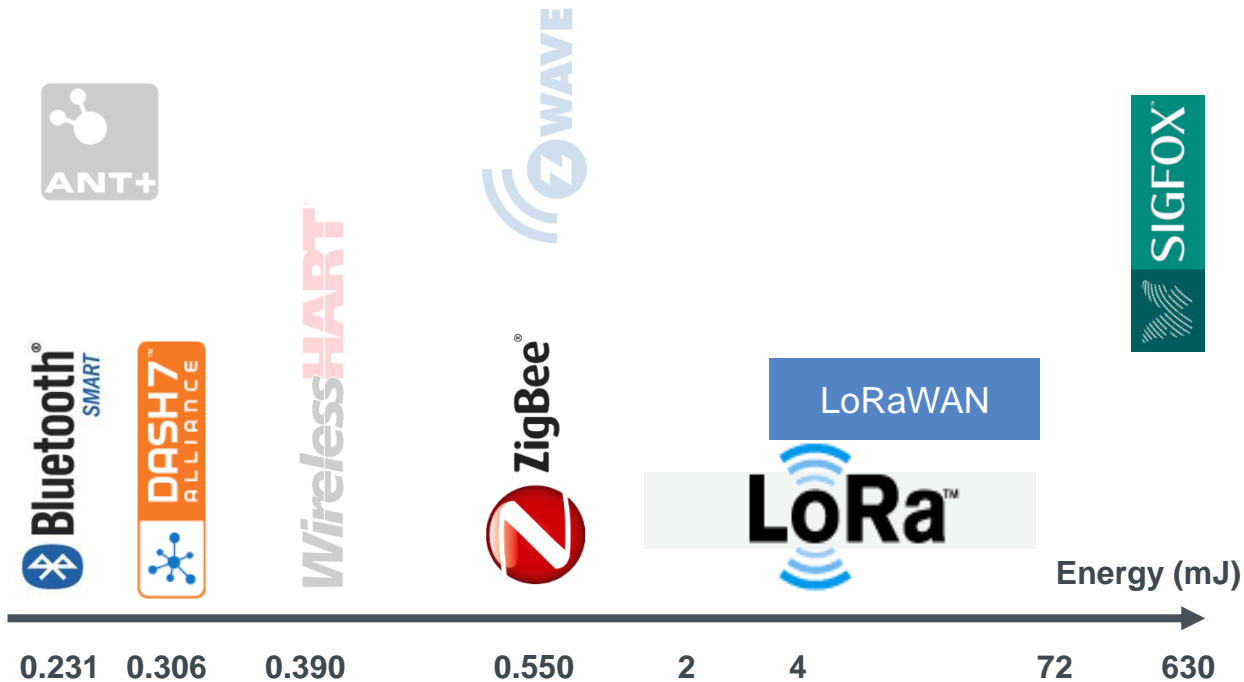
# Standardization



WirelessHART®



# ~~Energy~~ Power Consumption



**1**

**Birth**

Form question in  
your mind



**2**

**Evaluate**

Is it a reasonable  
question?



**3**

**Remember**

Until you can  
ask the question



**4**

**Courage**

To ask the  
question out loud



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