# LoRa IoT MREŽA TELEKOMA SRBIJA

Nada Petrović

Primena LPWAN (Low Power Wide Area Networks) u domenu IoT (Internet of Things)
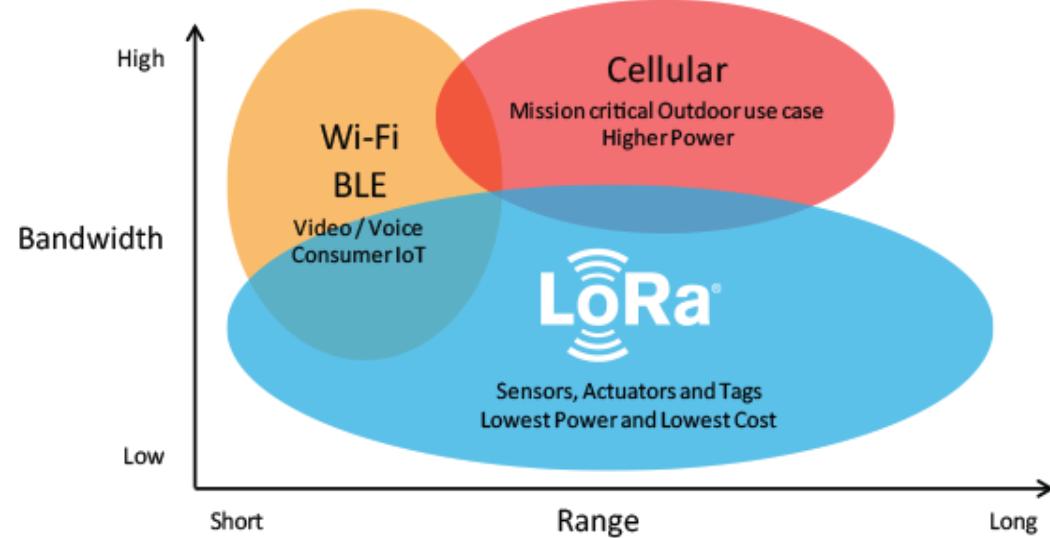

- Autonomno napajanje uređaja i višegodišnji životni vek baterije
- Podrška za velika rastojanja između krajnjeg i pristupnog uređaja (>10km)
- Visoka osetljivost na nivo signala

Arhitektura LoRa LPWAN
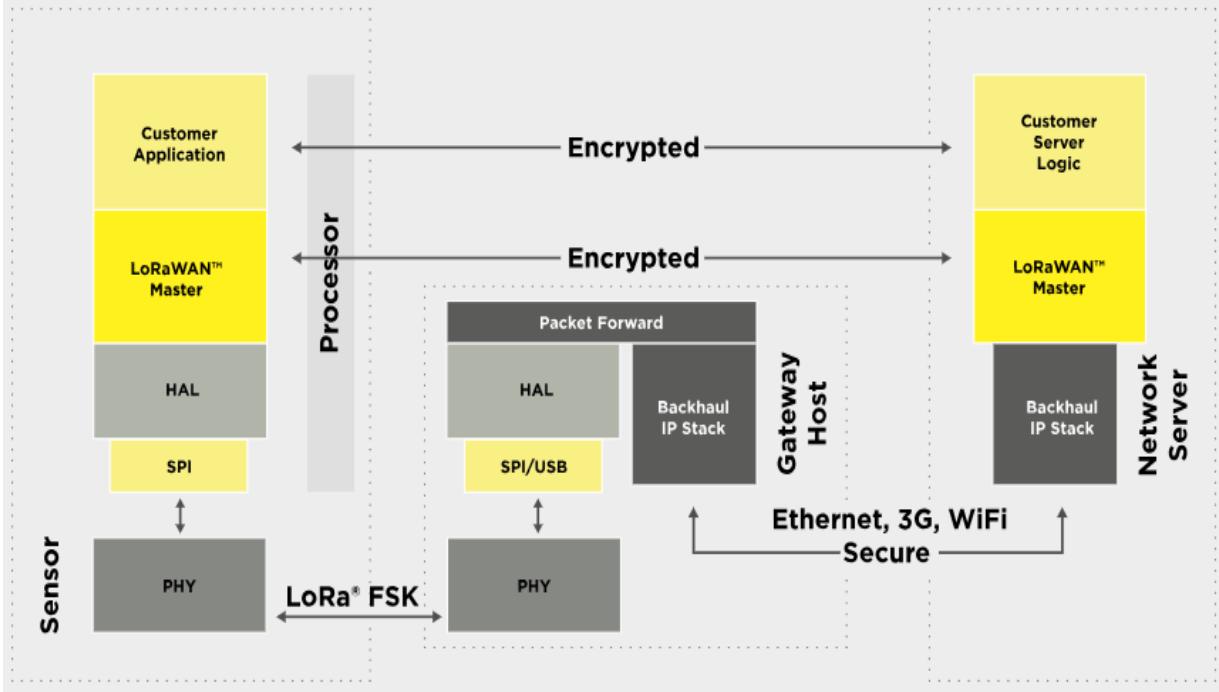
- *Gateway* je *Packet Forwarder* od krajnjeg uređaja do mrežnog servera

- Isti paket može da bude prenesen preko više GW-ja. Mrežni server vrši selekciju

- Mrežni server šalje pakete aplikativnom serveru, koji obavlja dekodovanje podataka

Komponente LoRa mreže TS
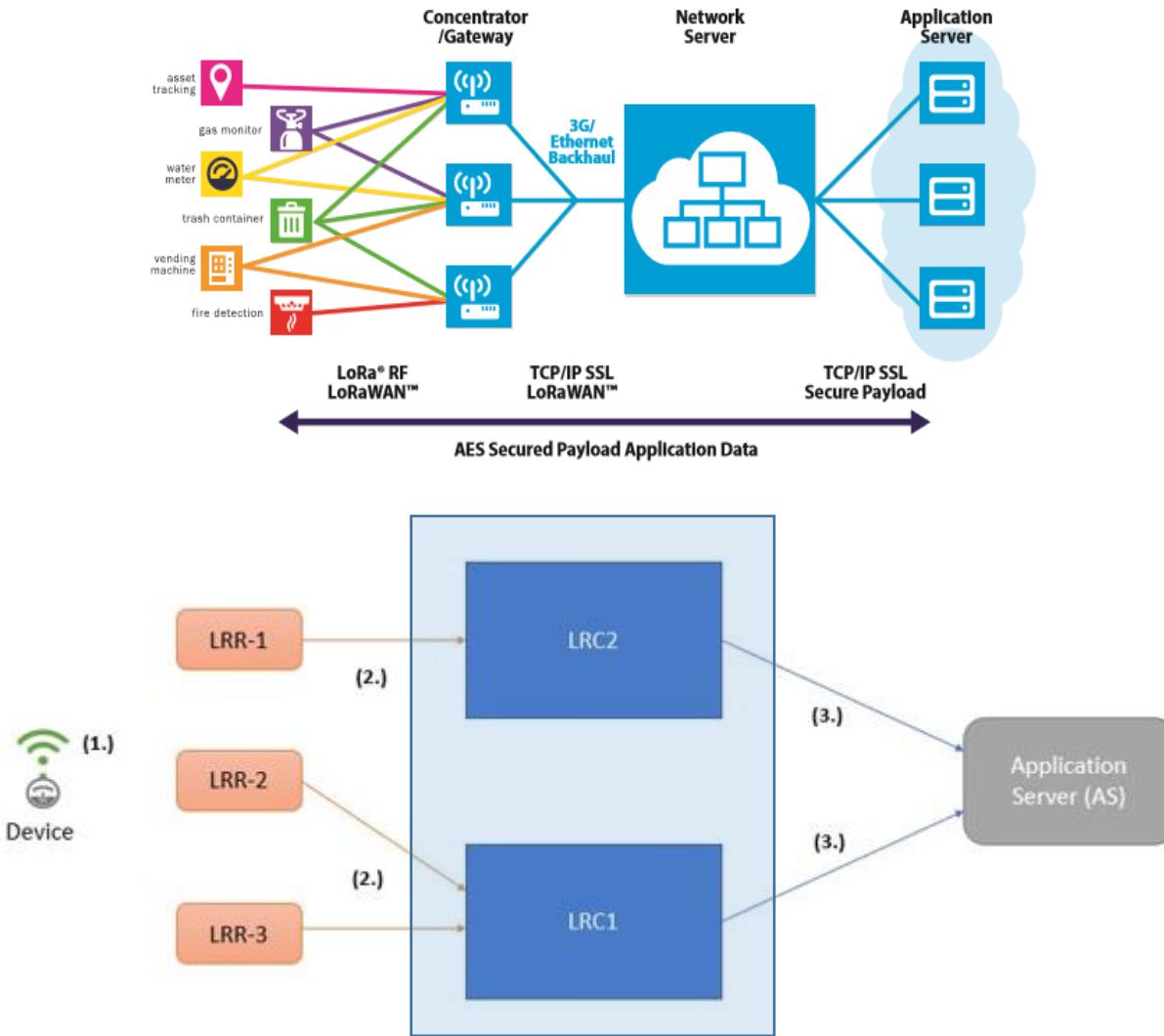
- LoRa GW-ji instalirani uz bazne stanice, sa omnidirekcionim antenama

- ~200 GW obezbeđuje signal na teritoriji Beograda - *Ufispace* LRR

- Transport kroz IP/MPLS mrežu Telekoma Srbija do mrežnog servera

- Mrežni server – *Actility ThingPark Wireless* LRC (active/standby)

- Aplikativni serveri i baze u *Cloud* infrastrukturi i kod partnera

Parametri radio pristupne mreže

Transmitter side:

- **Conducted Power:** TX Power out of the radio board, at antenna connector
- **ERP:** Equivalent Radiated Power, antenna gain expressed in dBd relative to half wave dipole antenna. ERP = TX Power – cable loss + antenna gain (dBd)
- **EIRP:** Equivalent Isotropically Radiated Power, antenna gain expressed in dBi relative to isotropic antenna radiating in all directions. EIRP = TX Power – cable loss + antenna gain (dBi)
    - EIRP = ERP + 2.15dB

Receiver side:

- **SNR:** Signal To Noise Ratio = S/(I+N) => determines the quality of the reception
- **ESP:** Estimated Signal Power = received signal strength = S
    - ESP = Tx EIRP – Path Loss + Rx antenna gain
    - ESP = RSSI – 10*LOG(1 + $10^{(-SNR/10)}$)
- **RSSI:** Received Signal Strength Indicator = S + I + N

Radio pristupna mreža – teorijske vrednosti

$$P_{Sensitivity} = -174 + NF + 10 \cdot \log_{10}^{BW} + SNR$$

Thermal noise in dBm → -174

System Bandwidth → BW

Noise Figure → NF

Signal To Noise Ratio → SNR

3.12.1 125kHz mode: IF8, IF[0 to 7] paths

SF	Data rate (bit/sec)	Sensitivity (dBm)
7	5469	-126.5
8	3125	-129.0
9	1758	-131.5
10	977	-134.0
11	537	-136.5
12	293	-139.5

Table 12 Sensitivity with 125 kHz mode

SpreadingFactor (RegModulationCfg)	Spreading Factor (Chips / symbol)	LoRa Demodulator SNR
6	64	-5 dB
7	128	-7.5 dB
8	256	-10 dB
9	512	-12.5 dB
10	1024	-15 dB
11	2048	-17.5 dB
12	4096	-20 dB

From SX1301 Datasheet (http://www.semtech.com/images/datasheet/sx1301.pdf)

Radio pristupna mreža - modulacija

- Spread Spectrum technique is highly immune against interference and allows operating at very low SNR ranges (down to -20dB)

- Chirp Spread Spectrum (CSS) is adopted by LoRa™ modulation, where spreading is achieved by generating a chirp signal that continuously varies in frequency

- Chip Rate (R_c) = Bandwidth (125KHz)

- Symbol Rate (R_s) = R_c / 2^{SF}
  - SF = Spreading Factor (7...12)
  - SF are orthogonal on each other => no interference

- Bit Rate (R_b) = R_s * SF * CR
  - CR = Code Rate = 4/5

Chirp Signal
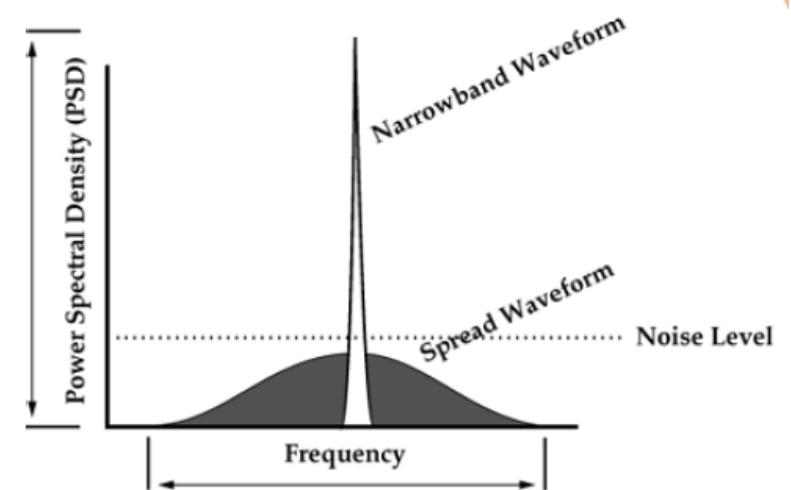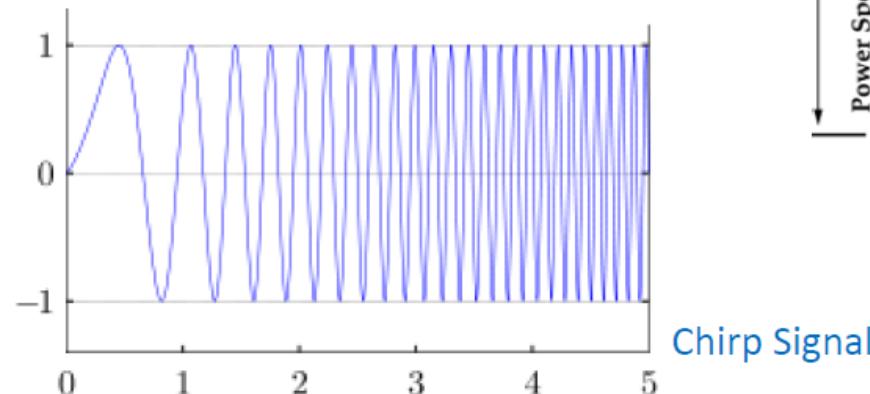
Parametri radio pristupne mreže

EU Data rate	Payload Data rate (bit/s)	Time on Air (ms)	Gateway sensitivity (dBm)	End-device sensitivity (dBm)
DR0 (SF12 / 125kHz)	293	1400	-147	-138
DR1 (SF11 / 125kHz)	540	740	-144.5	-135.5
DR2 (SF10 / 125kHz)	980	370	-142	-133
DR3 (SF9 / 125kHz)	1760	200	-139.5	-130.5
DR4 (SF8 / 125kHz)	3125	100	-137	-128
DR5 (SF7 / 125kHz)	5470	56	-134.5	-125.5
DR6 (SF7-250kHz)	11000	28	-131.5	-122.5
DR7 (FSK50)	50000	6	-116	-107

Gateway sensitivity figures assume +6dBi antenna
User applicative payload = 10 bytes

Osnovni slojevi LoRa komunikacionog uređaja

Application			
LoRa® MAC			
MAC options			
Class A (Baseline)	Class B (Baseline)	Class C (Continuous)	
LoRa® Modulation			
Regional ISM band			
EU 868	EU 433	US 915	AS 430	—
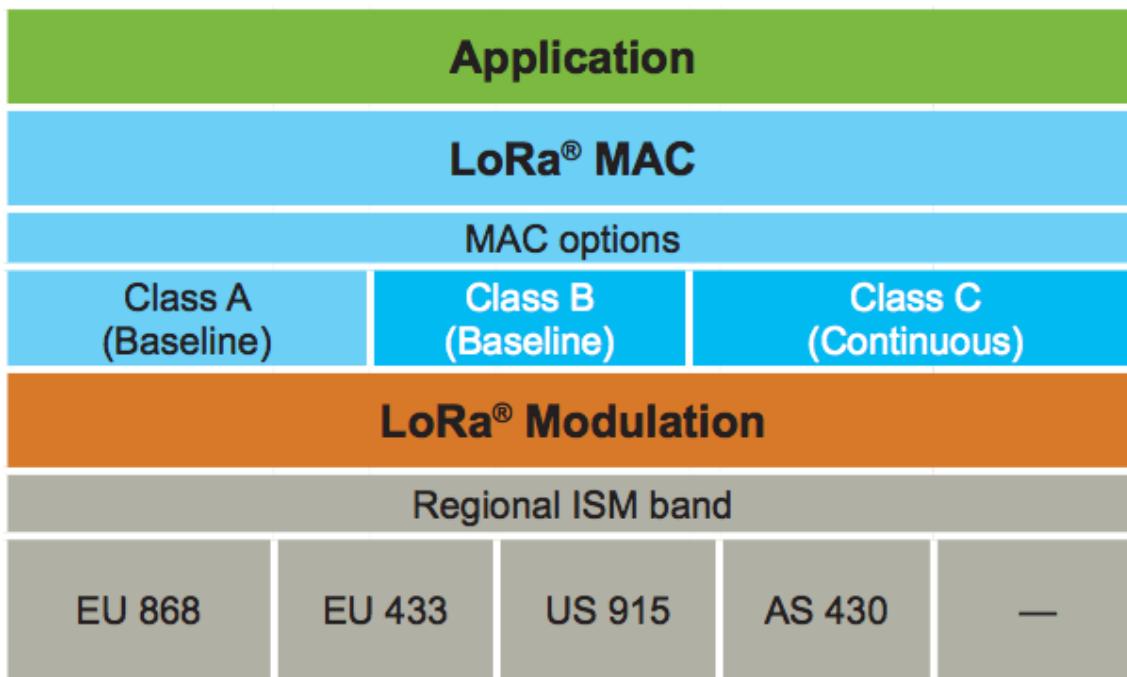
- Medium Access Control (MAC) sloj je zadužen za komunikaciju sa LoRaWAN mrežnim serverom

Struktura poruke sa LoRaWAN uređaja

Frame type value B₇ b₆ b₅	Description
000	Join Request
001	Join Accept
010	Unconfirmed Data
011	Confirmed Data
011...110	Reserved for future use
111	Proprietary

Frame type	RFU	Major version

1		4
MHDR	Data message	32 bit MIC

7..23	0..1	
FHDR	Port	Frm_Payload

4	1	2	0..15
DevAddr	FCtrl	FCnt	FOpts

Bits	7	6	5	4	3..0
content	ADR	ADRAC KReq	ACK	Frame pending	FOpts Len
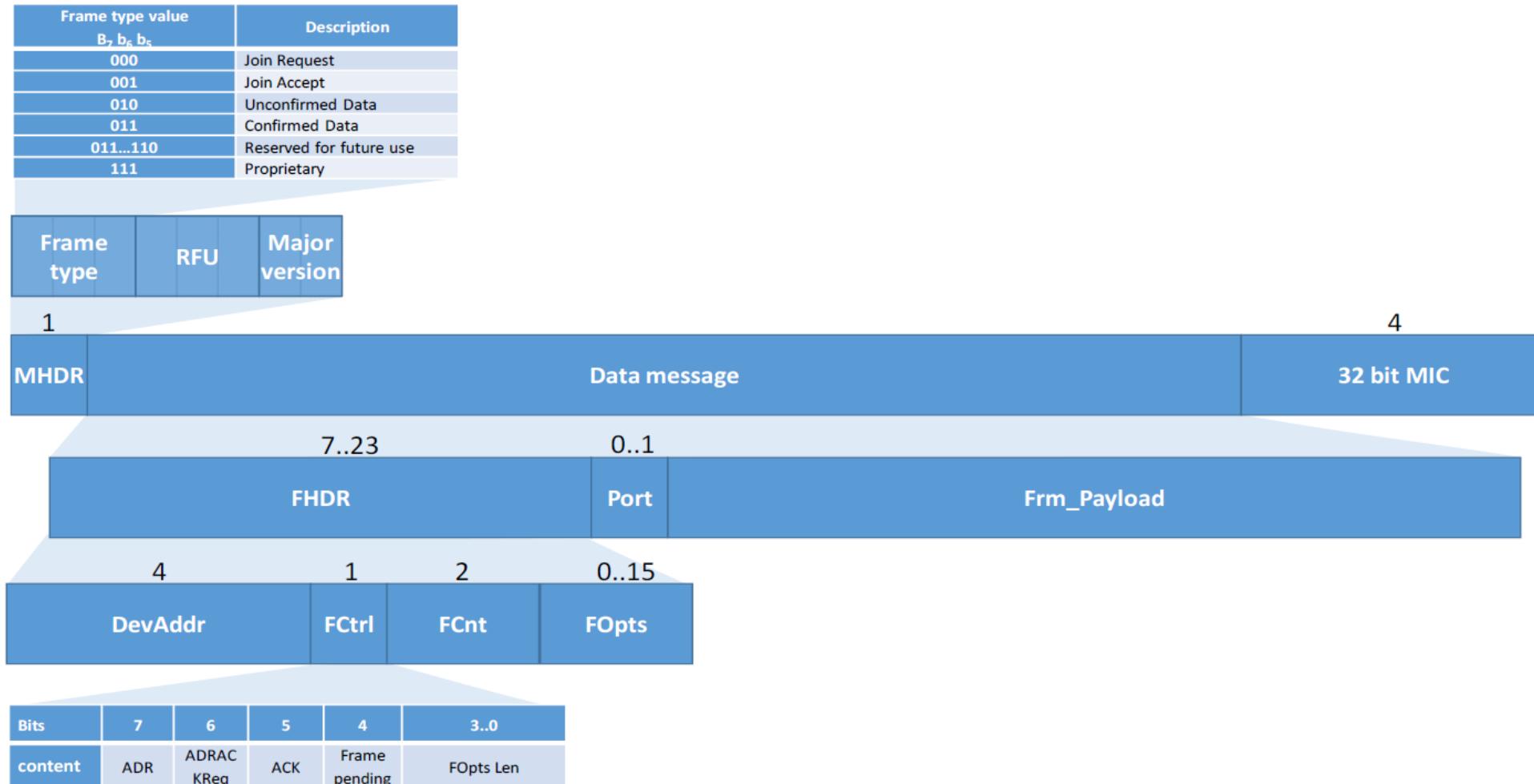
LoRaWAN klase uređaja

Class name	Intended usage
A (« all »)	**Battery powered sensors**, or actuators with no latency constraint Most energy efficient communication class. Must be supported by all devices
B (« beacon »)	**Battery powered actuators** Energy efficient communication class for latency controlled downlink. Based on slotted communication synchronized with a network beacon.
C (« continuous »)	**Mains powered actuators** Devices which can afford to listen continuously. No latency for downlink communication.

Katalog LoRaWAN profila uređaja na TS mrežnom serveru

commercialName	ID	typeMAC	vendor/commerc	vendor/ID	connectivity	macMi	defaultIsmBands-name
LoRaWAN 1.0.2 - class C - Rx2_SF12	LORA/GenericC.1_KR920_Rx2-SF12	LoRaMAC	Generic	generic	LORAWAN	4	KR920-923 (KR920)
PM2.5 Temp Humidity - LS-113 - class A	GLBSAT/LS-113_A.1_EU	LoRaMAC	GlobalSat	globalsat	LORAWAN	3	EU863-870 (EU868)
LoRaWAN 1.0.2 - class A - Rx2_SF12	LORA/GenericA.1_CN470_Rx2-SF12	LoRaMAC	Generic	generic	LORAWAN	4	CN470-510 (CN470)
PM2.5 Temp Humidity - LS-113 - class C	GLBSAT/LS-113_C.1_EU	LoRaMAC	GlobalSat	globalsat	LORAWAN	3	EU863-870 (EU868)
LoRaWAN 1.0.2 - class C - Rx2_SF12	LORA/GenericC.1_CN470_Rx2-SF12	LoRaMAC	Generic	generic	LORAWAN	4	CN470-510 (CN470)
PM2.5 Temp Humidity - LS-113 - class A	GLBSAT/LS-113_A.1_US	LoRaMAC	GlobalSat	globalsat	LORAWAN	3	US902-915 (US915)
LoRaMote EU fw4 - class A	SMTC/LoRaMoteA.1_EU	LoRaMAC	Generic	generic	LORAWAN	3	EU863-870 (EU868)
PM2.5 Temp Humidity - LS-113 - class C	GLBSAT/LS-113_C.1_US	LoRaMAC	GlobalSat	globalsat	LORAWAN	3	US902-915 (US915)
LoRaMote EU fw4 - class C	SMTC/LoRaMoteC.1_EU	LoRaMAC	Generic	generic	LORAWAN	3	EU863-870 (EU868)
Combox L - CI-B	SLVRA/COMBOX-L_CI-B_A.1_EU	LoRaMAC	Solvera Lynx	solvera	LORAWAN	3	EU863-870 (EU868)
Watteco fw 3.2 - Generic - class A (deprecated)	WECO/GenericA.3.2_EU	WattecoMAC_3.2	Watteco/NKE	watteco/nke	LORAWAN	3	EU863-870 (EU868)
Combox L - DI-B	SLVRA/COMBOX-L_DI-B_A.1_EU	LoRaMAC	Solvera Lynx	solvera	LORAWAN	3	EU863-870 (EU868)
Watteco fw 3.2 - Generic - class C (deprecated)	WECO/GenericC.3.2_EU	WattecoMAC_3.2	Watteco/NKE	watteco/nke	LORAWAN	3	EU863-870 (EU868)
Combox L - 2T-B	SLVRA/COMBOX-L_2T-B_A.1_EU	LoRaMAC	Solvera Lynx	solvera	LORAWAN	3	EU863-870 (EU868)
Watteco fw 3.2 - Generic - class A (deprecated)	WECO/GenericA.3.2_US	WattecoMAC_3.2	Watteco/NKE	watteco/nke	LORAWAN	3	US902-915 (US915)
Smove	TWAVE/SmoveA.1_ETSI_Rx2-SF12	LoRaMAC	Twave Technolog	twave_tech	LORAWAN	3	EU863-870 (EU868)
Watteco fw 3.2 - Generic - class C (deprecated)	WECO/GenericC.3.2_US	WattecoMAC_3.2	Watteco/NKE	watteco/nke	LORAWAN	3	US902-915 (US915)
TBS-200	TBOTC/TBS200A.1_ETSI_Rx2-SF12	LoRaMAC	Turbo Technolog	turbo_tech	LORAWAN	3	EU863-870 (EU868)
Watteco fw 3.4 - Generic - class A	WECO/GenericA.3.4_EU	LoRaMAC	Watteco/NKE	watteco/nke	LORAWAN	3	EU863-870 (EU868)
Oyster Tracker	DMAT/OysterTrackerA.1_AS923_Rx2-SF10	LoRaMAC	Digital Matter	digital_matter	LORAWAN	4	AS923
Watteco fw 3.4 - Generic - class C	WECO/GenericC.3.4_EU	LoRaMAC	Watteco/NKE	watteco/nke	LORAWAN	3	EU863-870 (EU868)
FuelUp	FULLUP/FUELUPA.1_ETSI_Rx2-SF12	LoRaMAC	FullUp sprl	fullup	LORAWAN	3	EU863-870 (EU868)
Watteco fw 3.4 - Generic - class A	WECO/GenericA.3.4_US	LoRaMAC	Watteco/NKE	watteco/nke	LORAWAN	3	US902-915 (US915)
Watteco fw 3.4 - Generic - class C	WECO/GenericC.3.4_US	LoRaMAC	Watteco/NKE	watteco/nke	LORAWAN	3	US902-915 (US915)
Demonstrator	ADRF/DemonstratorA.1_EU	LoRaMAC	Adeunis RF	adeunisrf	LORAWAN	3	EU863-870 (EU868)
Test Device Profile	Test	LoRaMAC	Generic	generic	LORAWAN	3	
Field Test Device - class A	ADRF/FielTestDeviceA.1_EU	LoRaMAC	Adeunis RF	adeunisrf	LORAWAN	3	EU863-870 (EU868)
LoRaWAN 1.0.2 revA - class A - Rx2_SF12_Bitgear	Bitgear	LoRaMAC	Generic	generic	LORAWAN	4	EU863-870 (EU868)
Field Test Device - class C	ADRF/FielTestDeviceC.1_EU	LoRaMAC	Adeunis RF	adeunisrf	LORAWAN	3	EU863-870 (EU868)
Telekom Srbija MMD - 1.0.2 revA - class A - Rx2-S	TelekomSrbijaMMD1.0.2 revAclassA Rx2SF1	LoRaMAC	Generic	generic	LORAWAN	4	EU863-870 (EU868)
Field Test Device - class A	ADRF/FielTestDeviceA.1_US	LoRaMAC	Adeunis RF	adeunisrf	LORAWAN	3	US902-915 (US915)
mDot Box - class A - Agrosens	MT/mdotboxA.1_EU	LoRaMAC	Multitech	multitech	LORAWAN	3	EU863-870 (EU868)
Field Test Device - class C	ADRF/FielTestDeviceC.1_US	LoRaMAC	Adeunis RF	adeunisrf	LORAWAN	3	US902-915 (US915)
Telekom Srbija MMD - 1.1 - class A - Rx2-SF12	TelekomSrbija MMD1.1class ARx2-SF12	LoRaMAC	Bitgear	bitgear	LORAWAN	10	EU863-870 (EU868)
Generic Sensors - class A	ADRF/SensorsA.1_EU	LoRaMAC	Adeunis RF	adeunisrf	LORAWAN	3	EU863-870 (EU868)

LoRaWAN 1.0.2 revA generic profile 868mhz

Base station profile Ufispace macroMacro V2.1 R1

Base Station Installation Configuration

Power Supply Configuration:	Power Over Ethernet

Embedded GPS receiver configuration:	Present

LoRaWAN RF Hardware Configuration:	1 sector, 2 antennas, 1 board (mono-sector 2*8)

Antennas configuration: *

Name	Base Station Antenna Type	Gain (dBi)
A1	Omnidirectional	
A2	Omnidirectional	

Add   Remove

WAN Configuration:

Network Name	Network Connection Type
eth0	Ethernet
ppp0	GPRS

Add   Remove

LRC Configuration:

LRC Name	LRC ID
KAIOTLRC1	
KAIOTLRC2	

LoRa raspored kanala na 868mhz
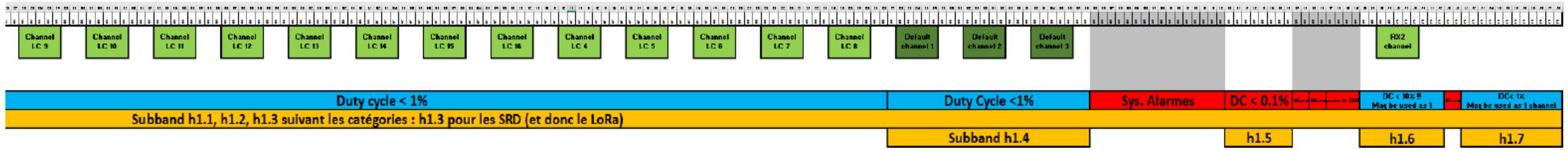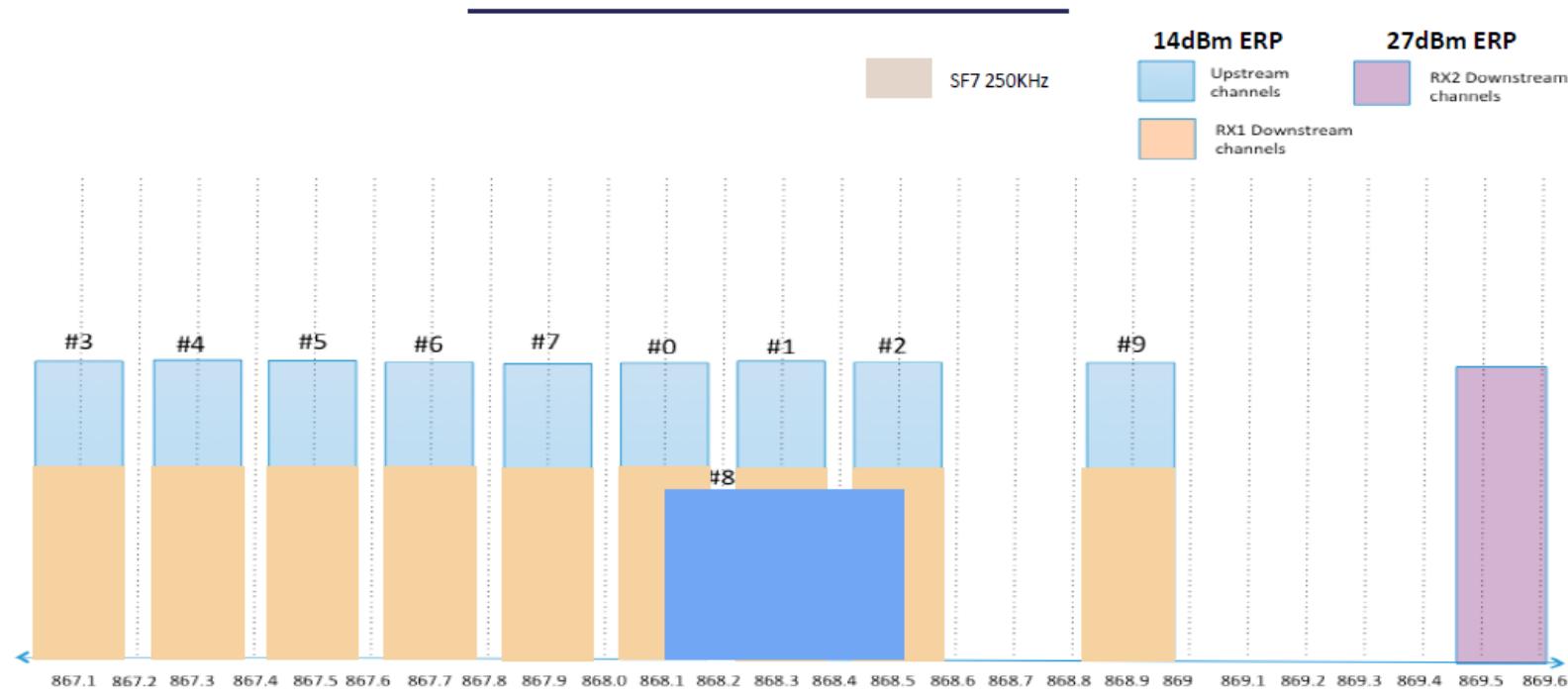
Korisnički interfejs za upravljanje uređajima

Provisioning uređaja

Aplikativna podrška

Logger

Busit AEP *Low code - no code*

- Analytics & cartography
- Real time process management
- Data visualization
- Data normalization & abstraction
- Connectivity
- Networks
- Devices & data sources
- API Management
- Security
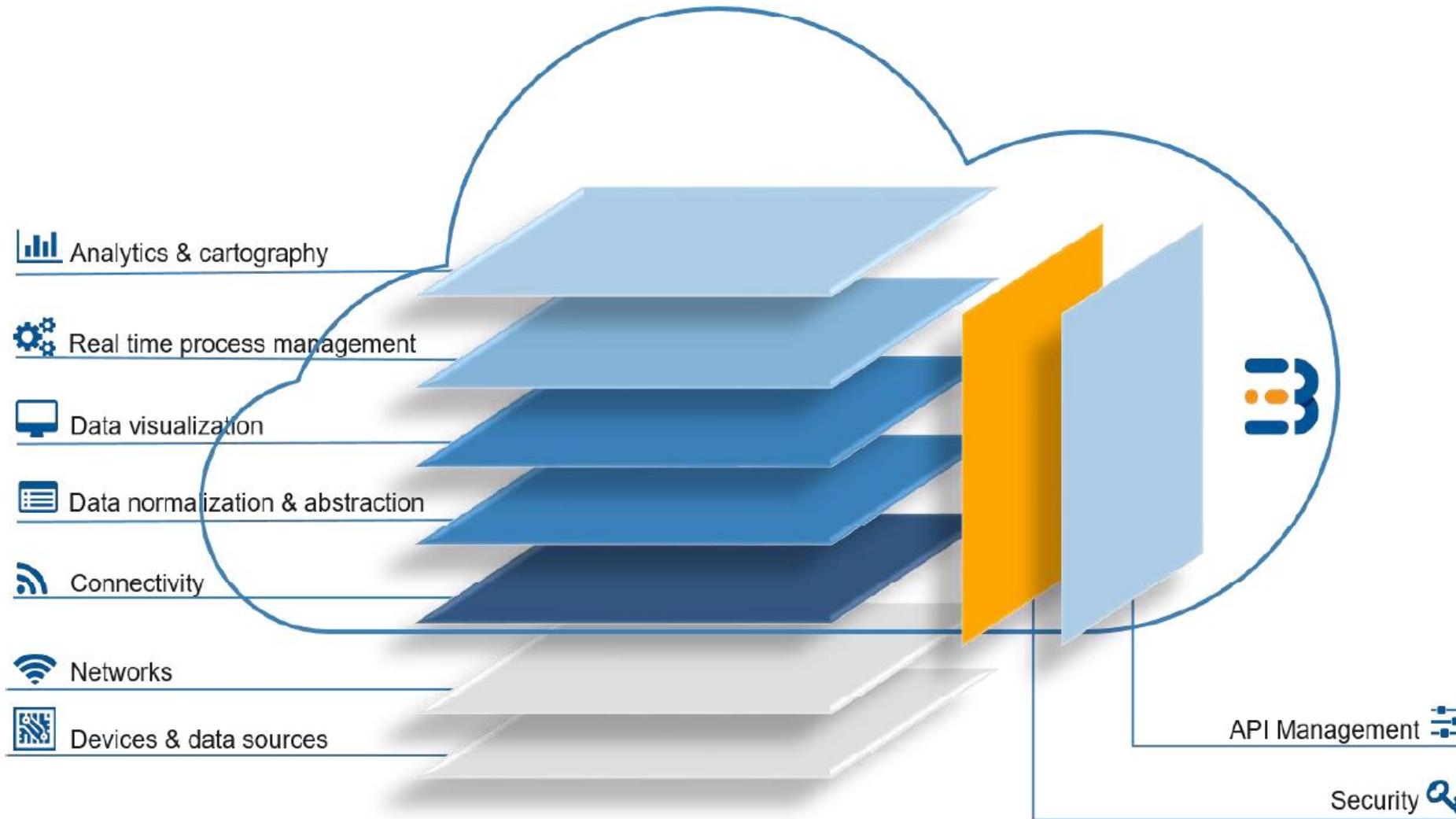
# Busit funkcionalni blokovi
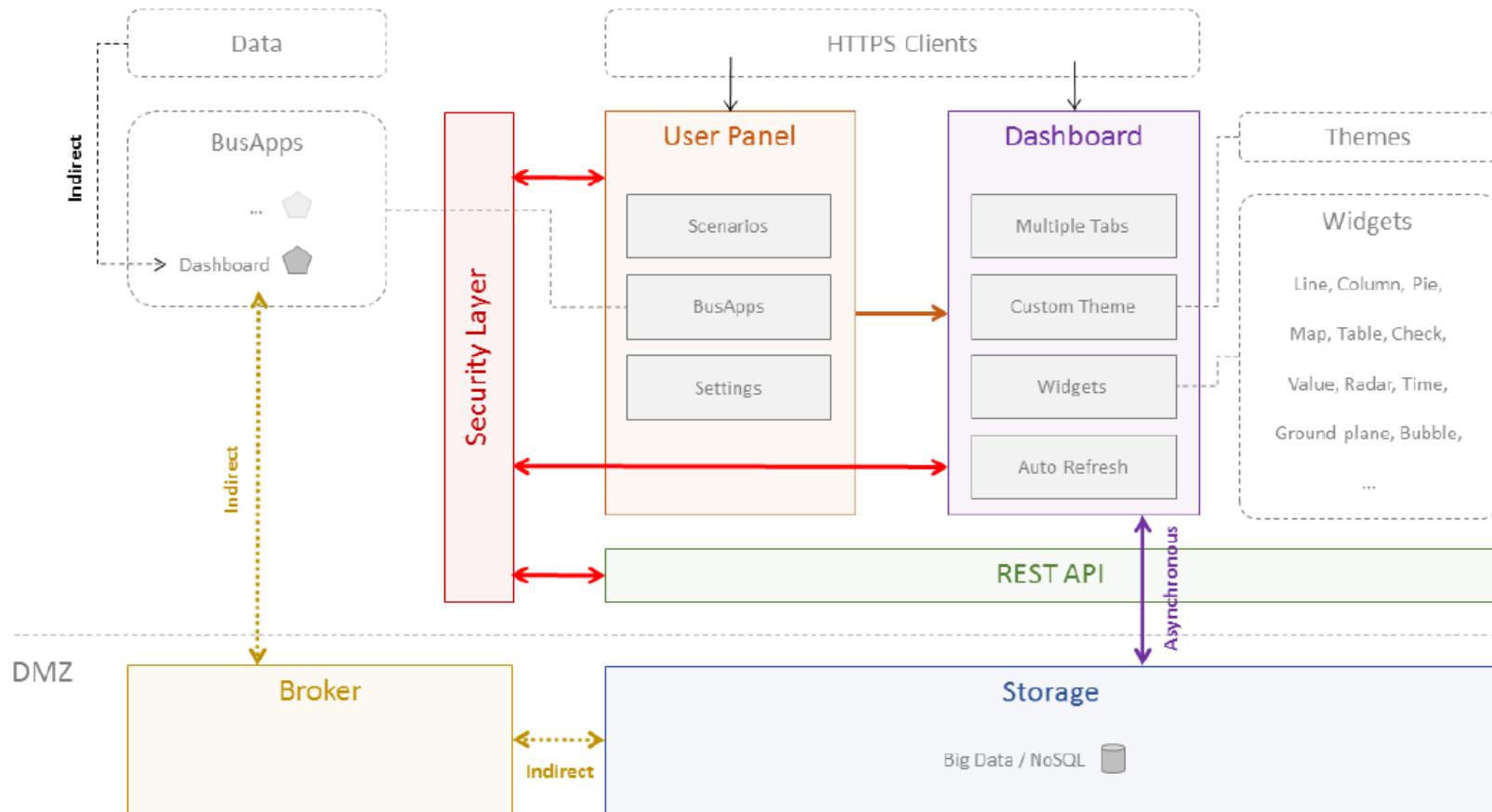
BusApps

1 Osnovni blok/modul u okviru platforme

2 BusApp-ovi služe za prikupljanje, obradu i prikaz podataka

3 Većina modula može da se iskoristi i za prikupljanje i za prikaz podataka

4 Na raspolaganju je 180 različitih BusApp-ova. Neki su posebno dizajnirani za prikupljanje ili obradu podataka sa konkretnih IoT uređaja

○ All types   ● Data sources   ○ Modifiers   ○ Endpoints

Debug	Actility Thingpark Generic	Data table	Generic producer
WebSocket	Dashboard action	Alarm	Inter-scenario
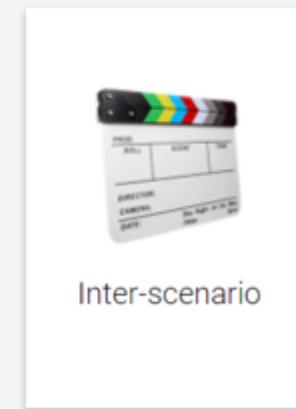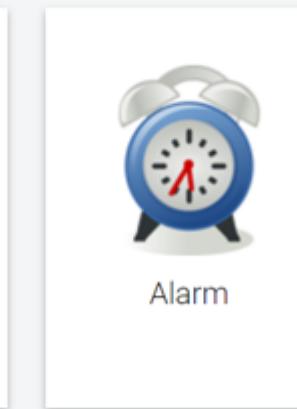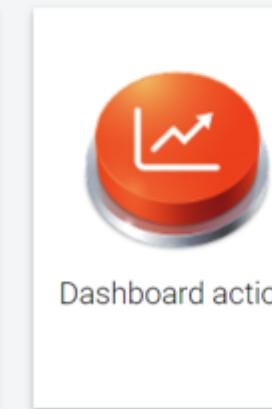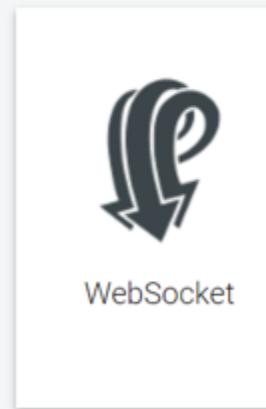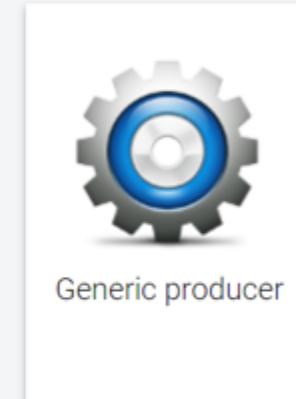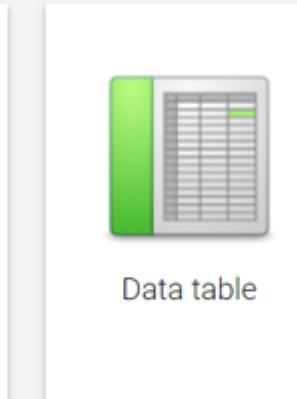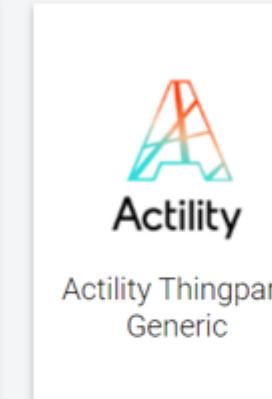
Scenario
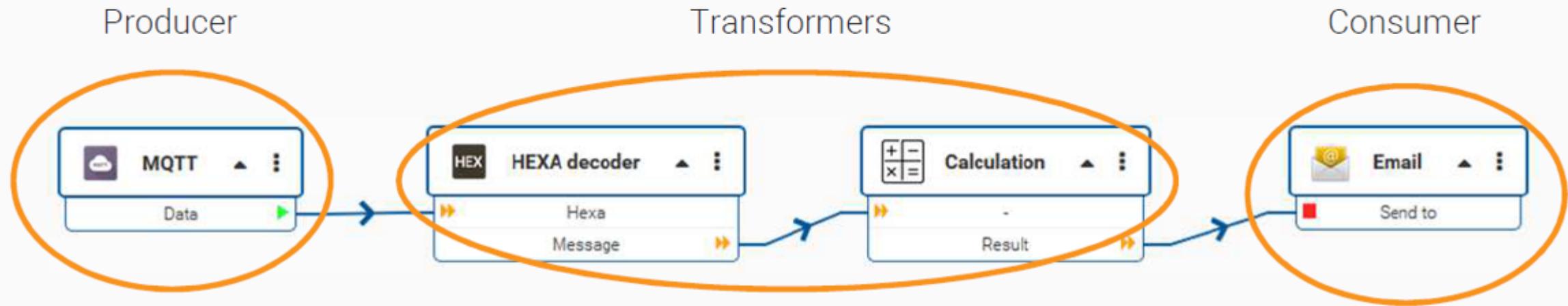
1 Definisanje protokola i uređaja sa kojih se podaci prikupljaju	**2** Obrada i normalizacija podataka sa definisanih uređaja	**3** Uvid u obrađene podatke

Prikaz podataka/dashboard
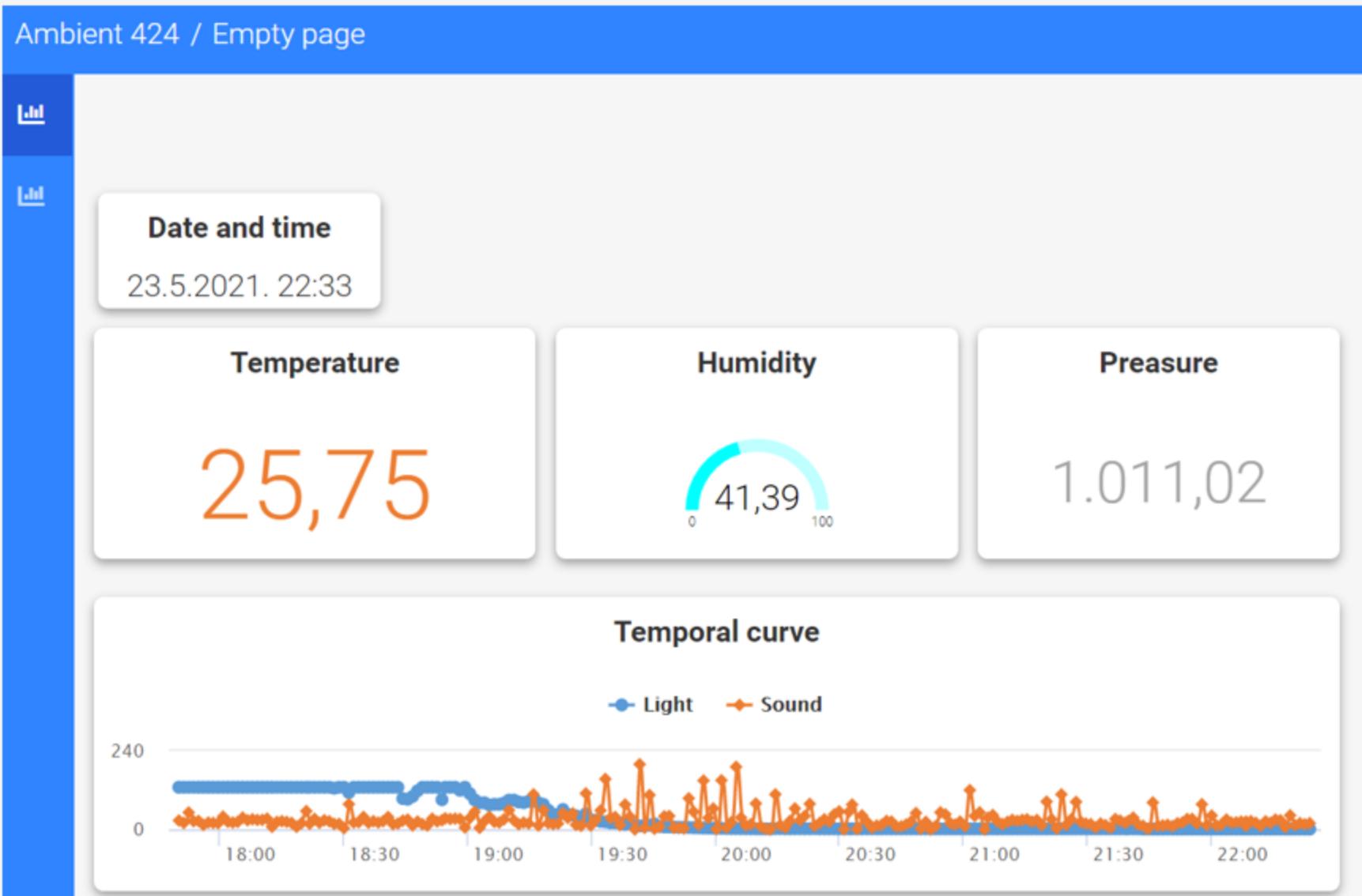
Sadržaj AllThingsTalk rapid development paketa

Contents of the Kit:

- 1* SODAQ Mbili, low power Arduino (ATmega 1284P) with 16kB, and 128kB flash memory.
- 1* LoRa Microchip RN2483 module with U.FL connector
- 1* Antenna (1/4 Wavelength) and U.FL to SMA pigtail
- 1* Power adaptor (Euro 220V/5V)
- 1* Mini USB cable
- 1* 1.5W Solar panel
- 1* Lithium Polymer Battery 1200mAh
- 1* Grove – Button
- 1* Grove – Light sensor
- 1* Grove – PIR motion sensor
- 1* Grove – Temperature – pressure – humidity sensor
- 1* Grove – 3-Axis Digital Accelerometer
- 1* Grove – Sound/Loudness Sensor
- 1* Grove – GPS module
- 1* Grove – Air quality sensor
- 1* Grove – Tilt switch
- 1* Grove – Magnetic door switch & screw connector
- 10* 5cm 4 Pin Grove Cables
- 5* 20cm 4 Pin Grove Cables

https://docs.allthingstalk.com/examples/hardware/get-started-sodaq-mbili/
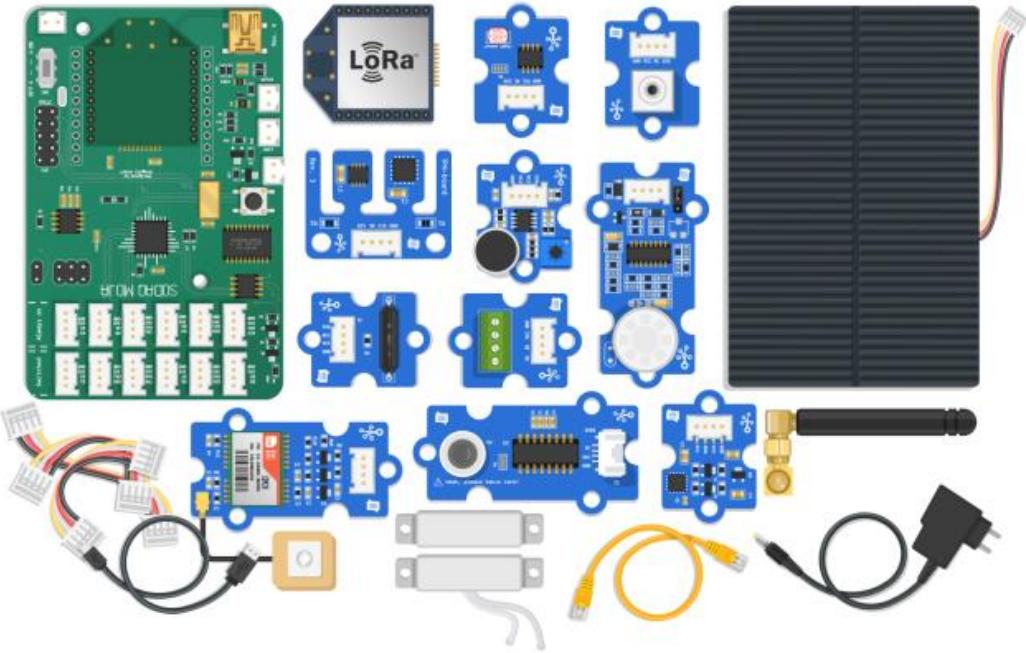
Rešenje za zaštitu kablovske infrastrukture

- Masovna primena LoRa senzorskih uređaja ispod čeličnih poklopaca

- Odabir senzora za specifične potrebe

- Zadovoljavajuće fizičke karakteristike otpornosti

- Web aplikacija za praćenje statusa u oknu na osnovu pristiglih poruka, autorizaciju ulazaka i generisanje alarma

- Mobilna aplikacija za autorizaciju na terenu

Hvala na pažnji.