

Software Engineering Conference Russia 2017



October, 20 – 21 | St. Petersburg

Development Features of Heterogeneous Mesh Network in MACS RTOS



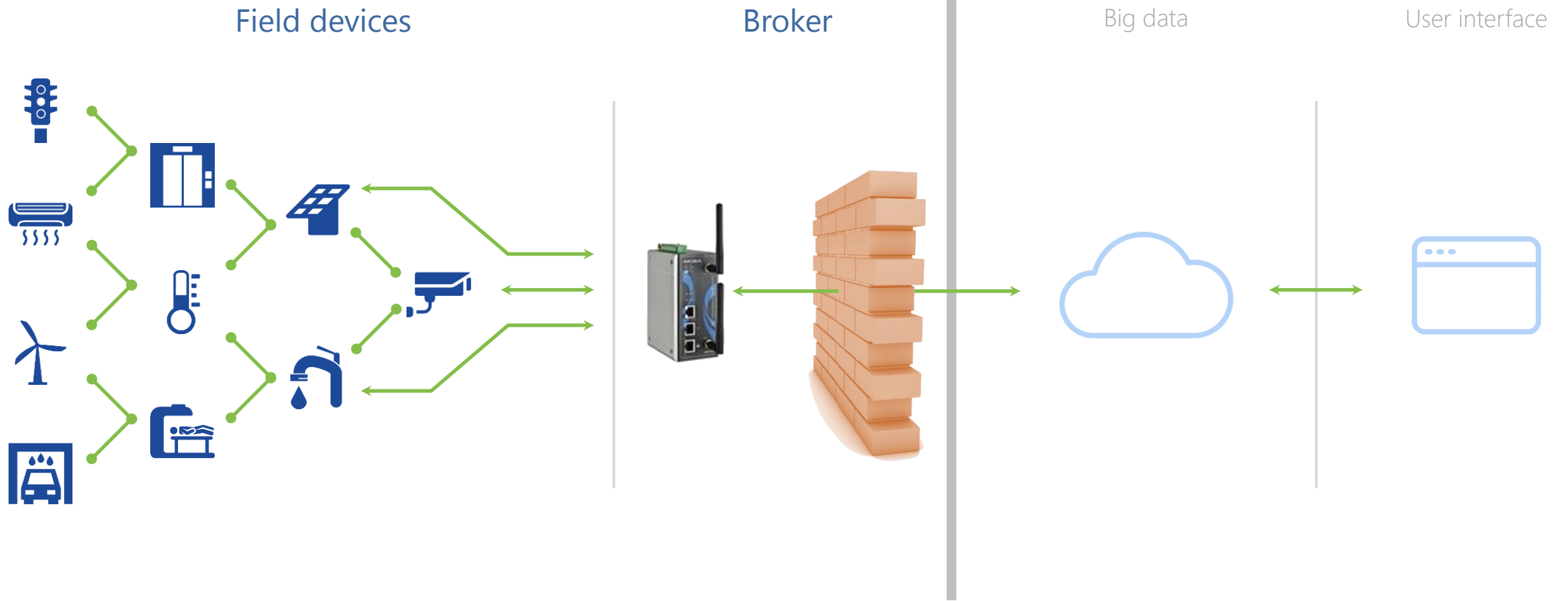
Alexey Spirkov





**IoT without MESH?
Possible, but not effective.**

IoT – Infrastructure



Communication layer of smart-building devices



Metering devices

MILANDR produced energy, water and gas metering devices



Dual channel heterogeneous communication

RF and PLC channels



Energy efficiently

Field devices should work years on batteries

Realtime Operating System

MACS

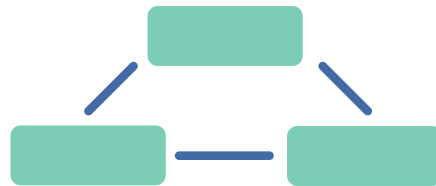
RTOS

Operating system for embedded multiagent systems, IT hardware and IoT

Usual RTOS functionality



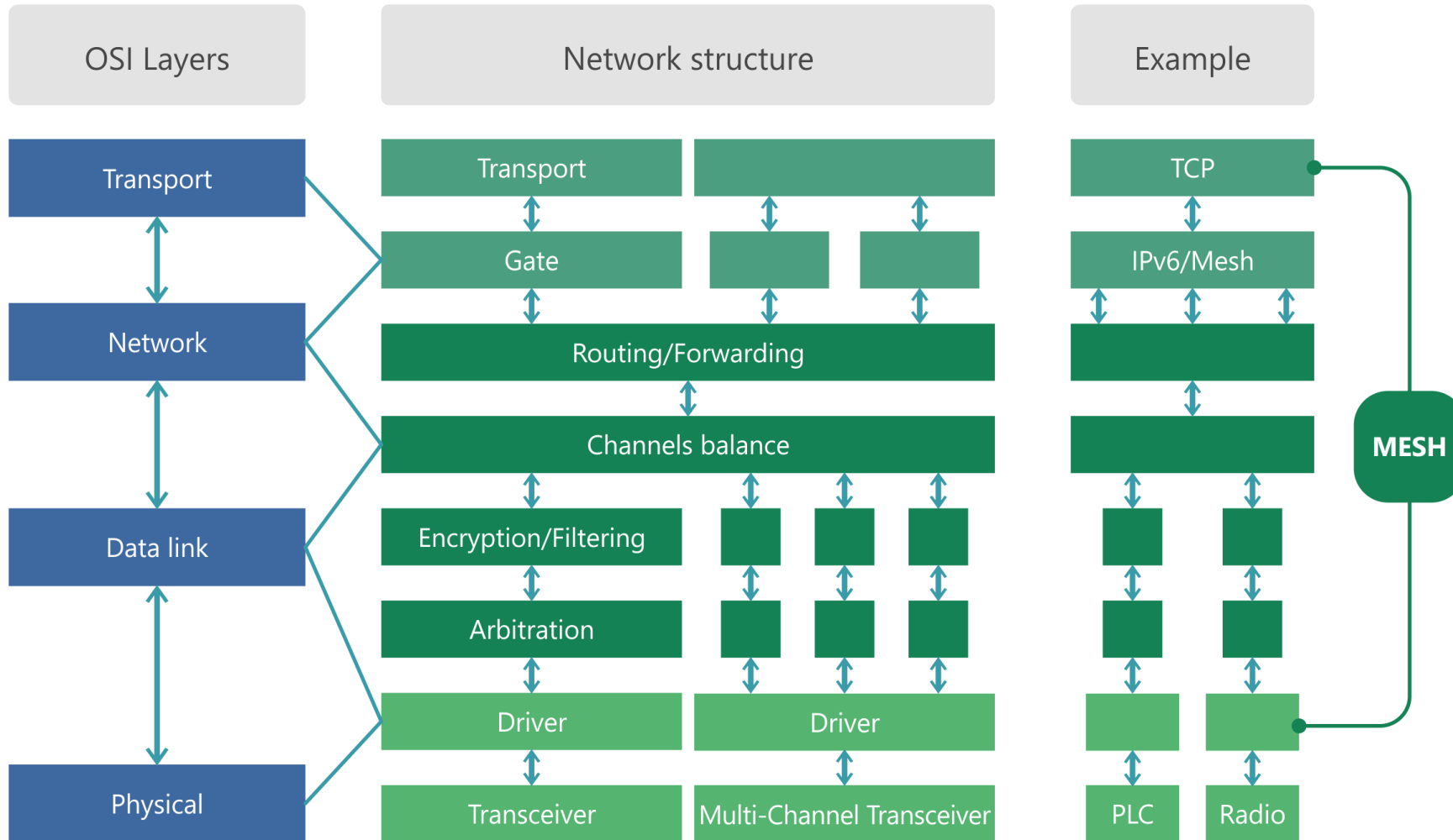
Unique collaboration possibilities



Russian hardware producers support



Heterogeneous Mesh Network Architecture



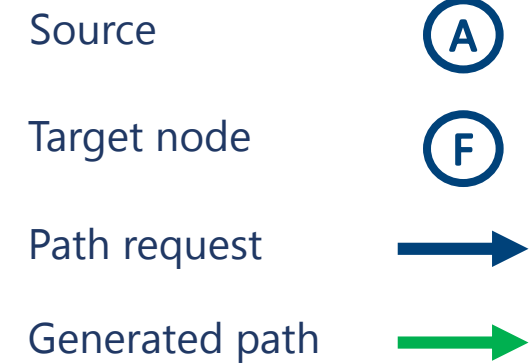
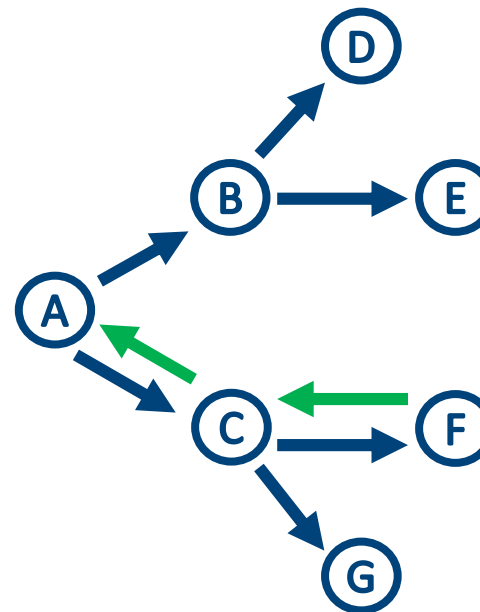
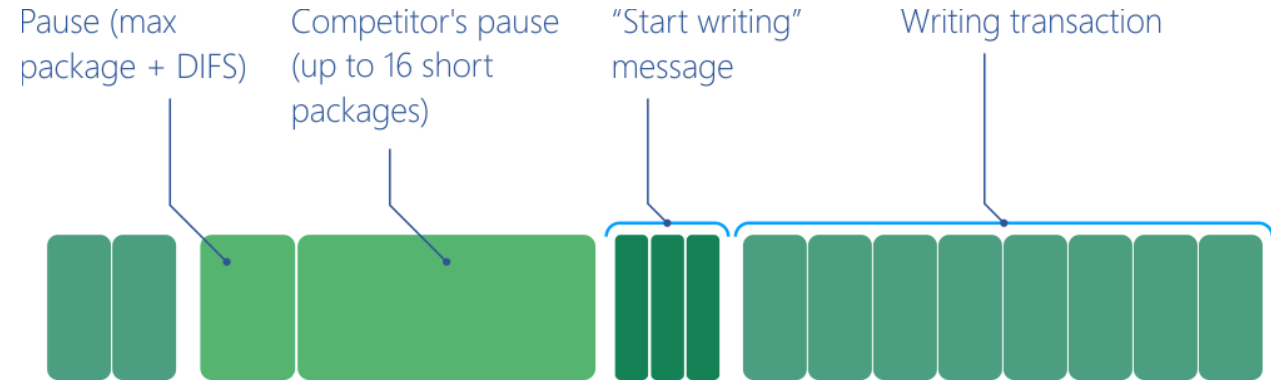
Mesh Algorithms

Arbitration:

- Packet DCF
- Packet TDMA
- Specialized methods

Routing:

- Hybrid
- LOADng (routing on demand)



Mesh Development

Special devices (12 pts.):

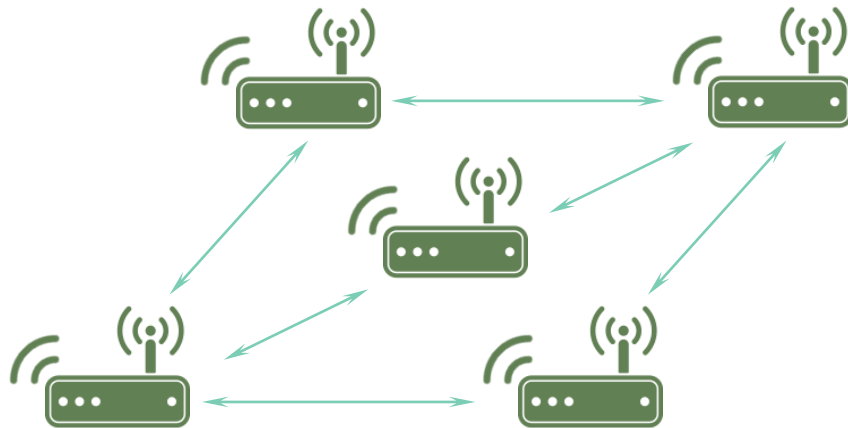
- Microcontroller: ARM Cortex-M4 (STM32F429)
- Radio: 2.4GHz (nRF24L01+)
- Battery power
- Remote programming via Wi-Fi (optional)
- Sensor display for user interface



Mesh Development

Configuration: Debugging and testing

- Central management
- Scripting for automation
- Gathering of network characteristics



Wi-Fi
hotspot



Server

Mesh Development

Software:

- Visualization
- Management
- Statistics
- Automation

The screenshot displays the 'Монитор Mesh-сети' (Mesh Network Monitor) software interface. It features a main window with two tabs: 'Графический вид' (Graphical view) and 'Табличный вид' (Table view). The graphical view shows a network of 32 nodes (represented by antenna icons) connected in a mesh topology. A central node (ID 21) is highlighted with a blue and green border, and several other nodes are connected to it. The table view on the right provides details for a selected station (ID 4), including its name, version, IP address, time, activity, power, frequency, speed, and report count.

Параметры	
ID станции	4
Имя	Floor #1 x 12.14 y 7.85
Версия ОС	1.5.0.1
IP станции	127.0.0.1
Время	0:08:19
Активность	1
Мощность	75
Частота	2400
Скорость	100000
Отчетов	175

The 'Логирование' (Logging) section shows a list of events, including station connections and node additions. The 'Выполнение скриптов...' (Script execution) section shows a script being executed, with a 'Старт...' (Start) button and a 'Стоп' (Stop) button.

The 'Окно выполнения скрипта' (Script execution window) shows the following log output:

```
start_log_id,4849717
send_id,4849717,Mesh_SetRSpeed 555
wait_sec,2
send_all,Mesh_Shutdown
wait_sec,5
send_id,4849717,Mesh_Powerup
wait_sec,5
send_id,4849717,Mesh_SetRSpeed 33
wait_sec,5
stop_log_id,4849717
wait_sec,2
```

Ожидая 5 секунд.
Станция ID : 4849717 подключена!
Начат лог станции ID :4849717
Команда станции ID: 4849717отправлена!
Ожидая 2 секунд.
Отправлены команды всем 7 станциям.
Ожидая 5 секунд.
Команда станции ID: 4849717отправлена!
Ожидая 5 секунд.
Команда станции ID: 4849717отправлена!
Ожидая 5 секунд.
Завершен лог станции ID :4849717
Ожидая 2 секунд.
СКРИПТ ЗАВЕРШЕН!

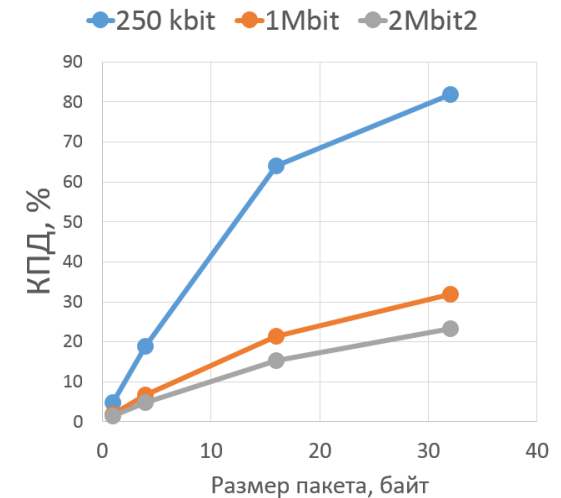
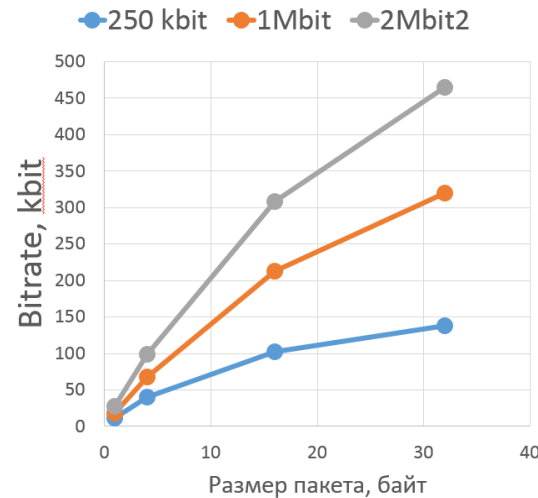
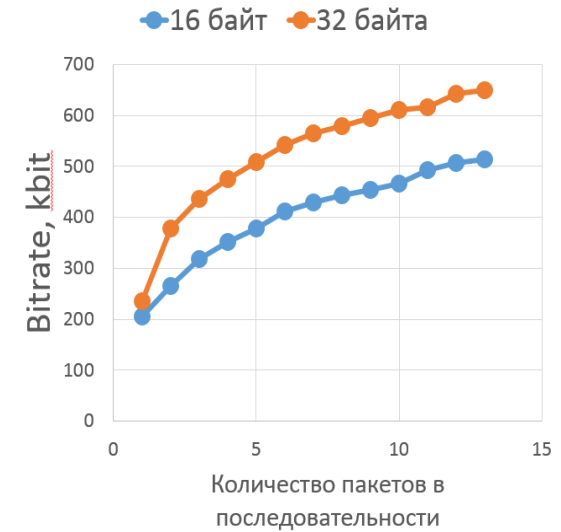
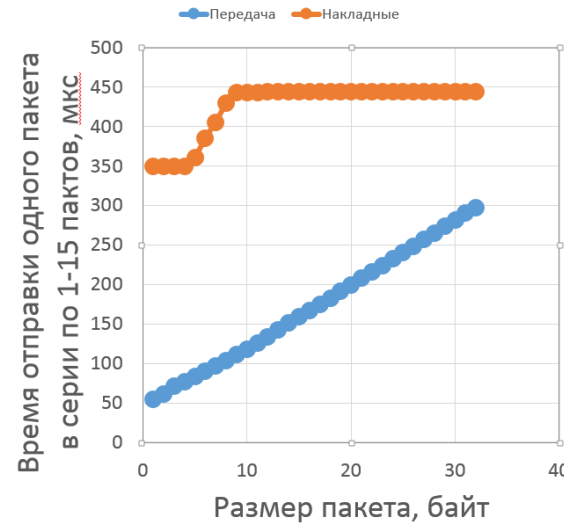
Imitation Model: Network Channels Unification

Universal modem

- Generic transceiver interface
- Guaranteed operation execution

Virtual transceiver

- Timing characteristics
- Specific functions and properties



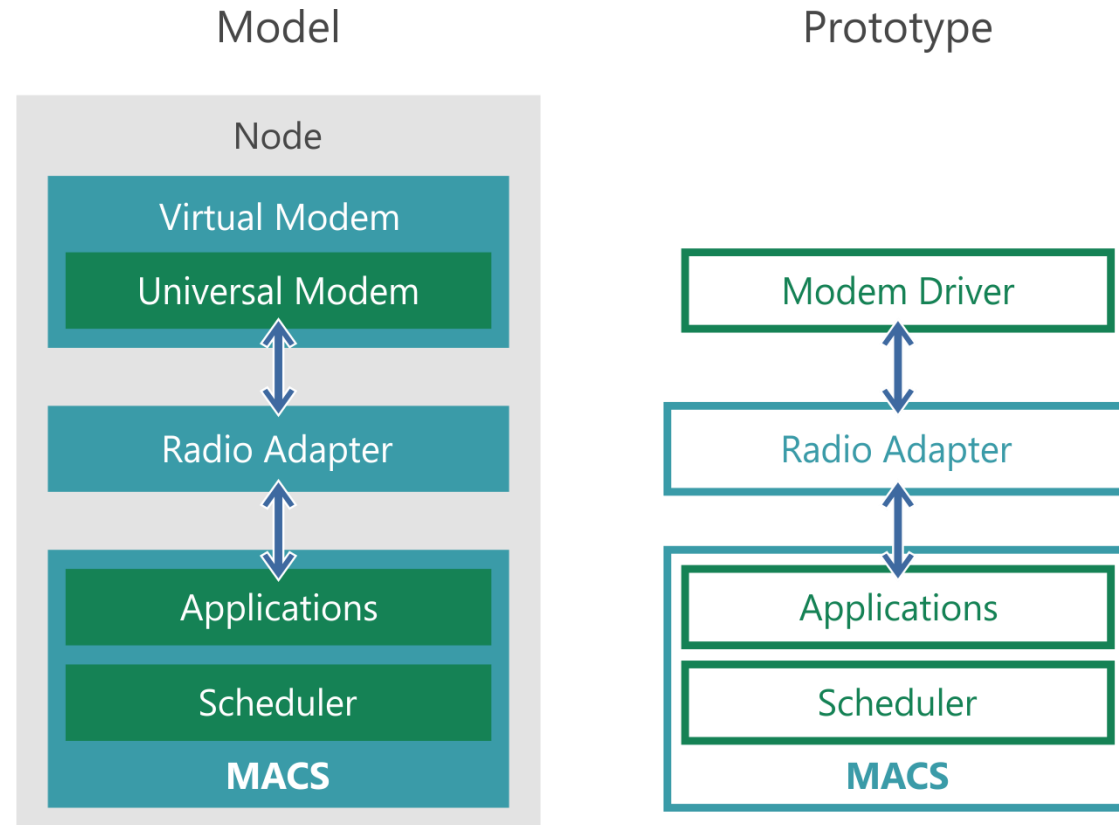
Imitation Model: Architecture

Structure of imitation model:

- Virtual transceiver
- Physical model
- Network configuration
- Node software
- Experiment manager
- Management interface

Main idea:

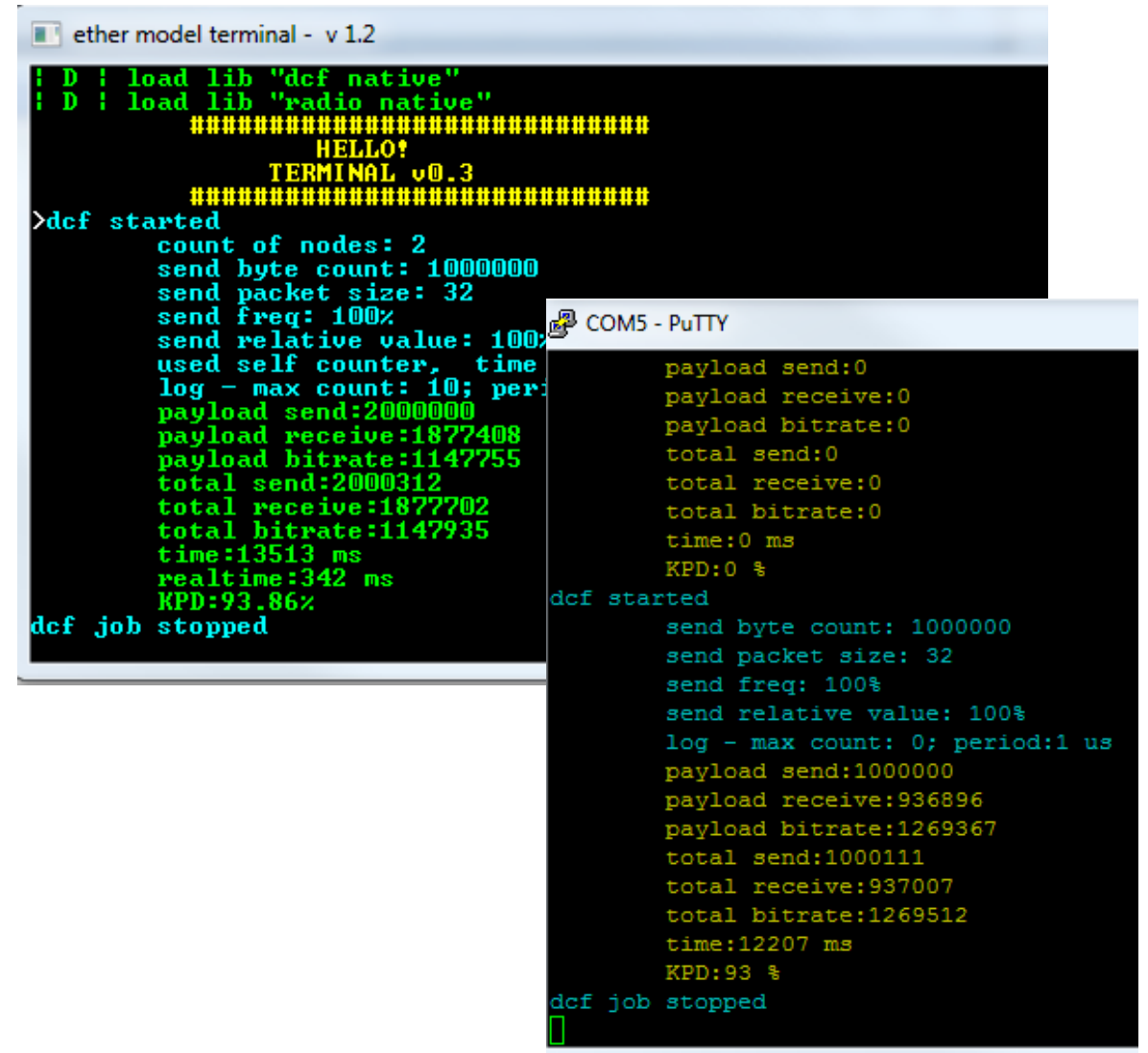
- Software identical up to peripheral drivers



Imitation Model: Validation

- Nodes: 2
- Speed of node: 2 Мбит/с
- Sending: continuous
- Packet size: 32 bytes
- Size of data: 1 000 000 bytes

	Model	Device
Received, [bytes]	938 704	936 896
Service, [bytes]	156	111
Time, [c]	13,513	12,207
Packet lost , [%]	6,13	6,31
Speed, [bit/s]	1 147 935	1 269 512

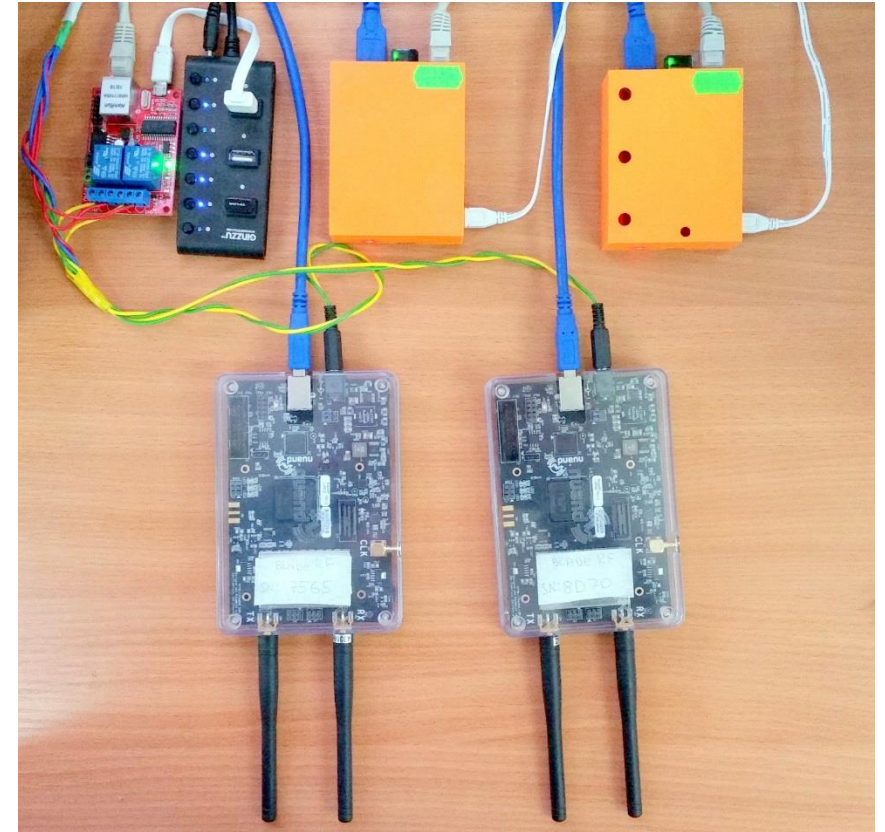


```
ether model terminal - v 1.2
! D ! load lib "dcf native"
! D ! load lib "radio native"
#####
HELLO!
TERMINAL v0.3
#####
>dcf started
count of nodes: 2
send byte count: 1000000
send packet size: 32
send freq: 100%
send relative value: 100%
used self counter, time
log - max count: 10; per:
payload send:2000000
payload receive:1877408
payload bitrate:1147755
total send:2000312
total receive:1877702
total bitrate:1147935
time:13513 ms
realtime:342 ms
KPD:93.86%
dcf job stopped

COM5 - PuTTY
payload send:0
payload receive:0
payload bitrate:0
total send:0
total receive:0
total bitrate:0
time:0 ms
KPD:0 %
dcf started
send byte count: 1000000
send packet size: 32
send freq: 100%
send relative value: 100%
log - max count: 0; period:1 us
payload send:1000000
payload receive:936896
payload bitrate:1269367
total send:1000111
total receive:937007
total bitrate:1269512
time:12207 ms
KPD:93 %
dcf job stopped
```

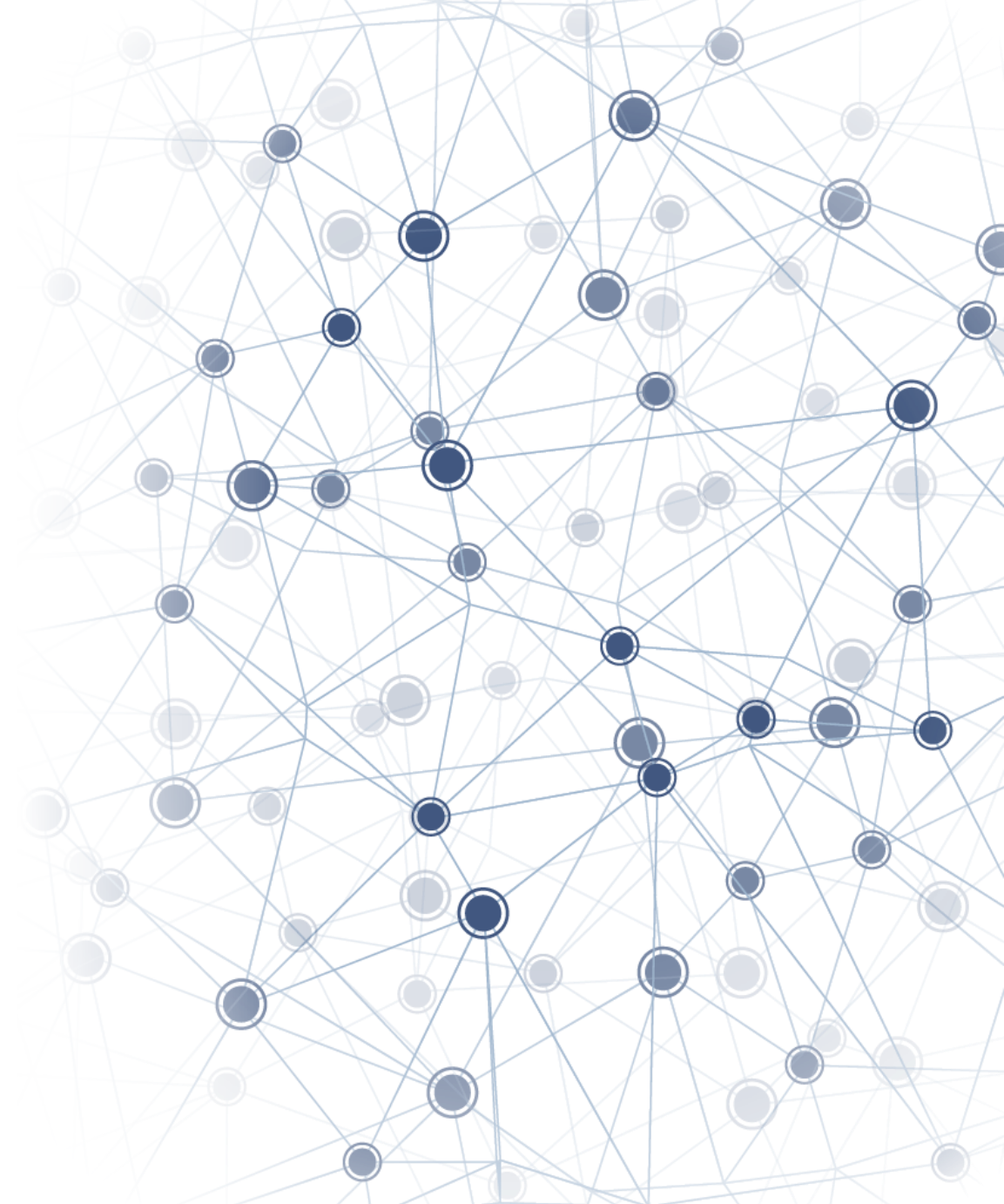
SDR Modem

- Parallel independent channels
- Hardware retranslation between channels
- Cognitive functions – adaptation to environment (modulation/speed etc.)
- Hardware encryption
- High speed
- Flexible architecture
- Realization of time critical Mesh functions



Target Solution

- Milandr 1968BH034 DSP processor
- Standards:
 - IEEE 802.15.4 for RF
 - ITU-T G.9903 (based on IEEE 802.15.4) for PLC
- Data security:
 - LBP (LowPAN Bootstrapping Protocol)
 - EAP (Extensible Authentication Protocol) protocol



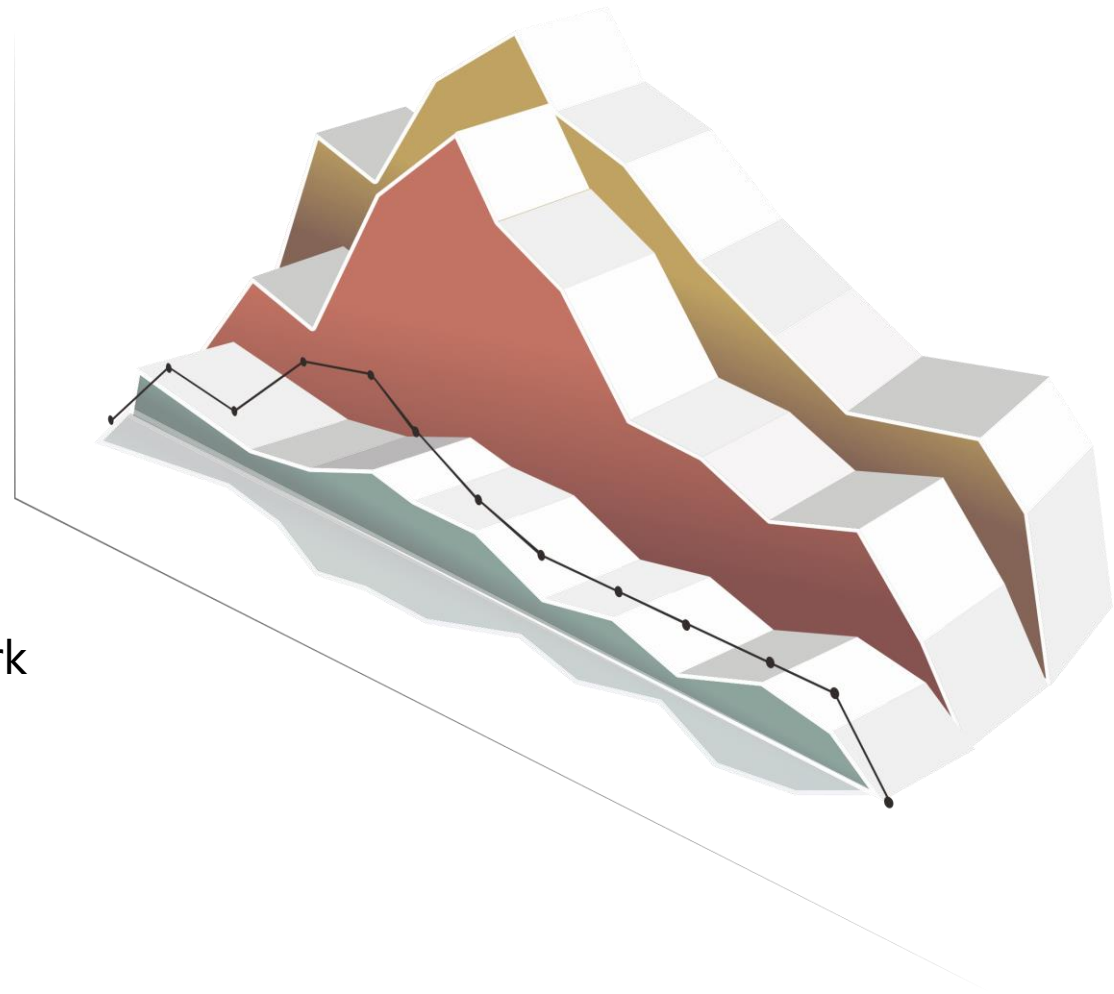
Simulation

- 500 – 5000 stations simultaneously
- End-point devices simulation
 - Impulse counter
 - Electricity meter
 - Data gathering point



Result Characteristics

- Nodes
 - in total - 231
 - ~40000 (for one data gathering point)
- Nominal speed:
 - PLC – 48 Kbit/sec
 - RF – 1,2 Kbit/sec
- Half-duplex
- Average speed in network: 10 Kbit/sec for 14 hops network (limited by low energy field devices)
- Average packet lost: 3%





ASTRO●SOFT

astrosoft.ru
(812) 494 9090