Development Features of Heterogeneous Mesh Network in MACS RTOS

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IoT without MESH?
Possible, but not effective.
IoT – Infrastructure

Field devices → Broker → Big data → User interface

- Field devices
- Broker
- Big data
- User interface
**Goal**

**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

OSI Layers
- Transport
- Network
- Data link
- Physical

Network structure
- Transport
- Gate
- Routing/Forwarding
- Channels balance
- Encryption/Filtering
- Arbitration
- Driver
- Transceiver
- Multi-Channel Transceiver

Example
- TCP
- IPv6/Mesh
- MESH
- PLC
- Radio
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
Mesh Development

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

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Model</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Received, [bytes]</td>
<td>938 704</td>
<td>936 896</td>
</tr>
<tr>
<td>Service, [bytes]</td>
<td>156</td>
<td>111</td>
</tr>
<tr>
<td>Time, [с]</td>
<td>13,513</td>
<td>12,207</td>
</tr>
<tr>
<td>Packet lost, [%]</td>
<td>6,13</td>
<td>6,31</td>
</tr>
<tr>
<td>Speed, [bit/s]</td>
<td>1 147 935</td>
<td>1 269 512</td>
</tr>
</tbody>
</table>
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%