# TELEGESIS CASE STUDY

**AN AUTOMATED WATER METER READING SYSTEM SIMPLIFIED by ZIGBEE**

***Special Points of Interest:***

- **Overview of TBN System**
- **Zigbee Technology**
- **Telegesis ETRX2 Modems**

## TELEGESIS GETS INTO HOT WATER.

**Monitoring and accurate accounting of utility consumption – whether electricity, gas, or water - is a strategically important task, affecting the economy of every country.**

TBN Energoservice is a Russian company that has specialised in metering and analysis of energy resource consumption for the past decade. TBN Energoservice offers its energy services to utility companies enabling their consumers to take an active role in energy saving programs by developing solutions to realise this aim.

Considerable TBN Energoservice company funds are invested in the development of Automatic Meter Reading (AMR) and Advanced Metering Infrastructure (AMI) systems using the latest technical developments. TBN engineers are currently implementing a major wireless water consumption AMR system based on ZigBee radio technology. The system uses ZigBee mesh networking software and silicon from Ember Corporation delivered in module form via the ETRX2 module produced by British Company Telegesis

**"GIS TBN ENERGO" information system**

In the Russian model water is pre-heated in dedicated power plants and pumped underground directly to consumers apartments. Historically, the provision of all water services – including hot water for central heating and washing – has been free of charge. To introduce a levy based system and to monitor usage of hot and cold water a metering scheme has been introduced.
TBN Energoservice delivers its energy service via its own back end information system – dubbed GIS TBN ENERGO; whilst there are many AMR systems in the market at the present time, GIS TBN ENERGO differs from most in that it offers a comprehensive approach.

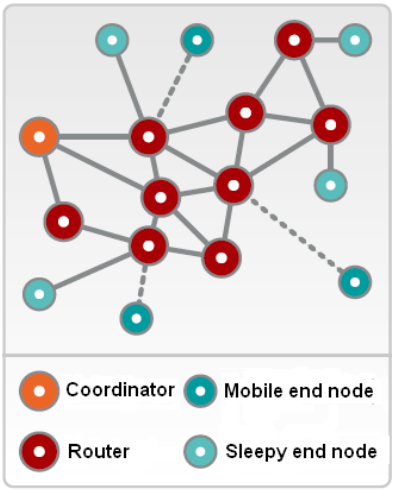
The TBN system includes the AMR subsystem, the dispatcher control subsystem - responsible for control of equipment states and failure detection, the data saving subsystem, and the analytic subsystem. From initial concept stage the GIS TBN ENERGO system has been designed to be truly scalable and can be implemented as a district, city, or regional scale system. Currently 50 district systems have already been put into the service in Moscow. During the last years TBN Energoservice has delivered systems to comply with the Moscow government program known as "Water meter into every municipal house".
Initially, TBN's AMR subsystem used one meter per house. This was followed by a wired data acquisition system with multiple apartment water meters per building. TBN Energoservice are now moving to a wireless AMR based on ZigBee technology.

**ZigBee Technology**

In order to simplify system implementation ZigBee wireless communication based on Telegesis ETRX2 modules using Embers technology was selected. The ZigBee mesh network topology (Fig. 1) can support a coordinator, multiple routers and multiple end devices (sleepy or mobile).

**Telegesis ETRX2 wireless modems**

Telegesis ETRX2 modules were chosen as the base components for the TBN wireless AMR subsystem (Fig. 2). Telegesis specialises in manufacturing wireless mesh networking modules based on Ember's chip set and are used in a wide range of implementations. Telegesis engineers were among the first to develop an 'AT' style command set for their radio modules effectively offering them as modems.

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# AMR AND AMI SOLUTIONS USING ZIGBEE

The Telegesis command layer for the ETRX2 module firmware forms a powerful software product providing comprehensive access to the mesh networking technology of Ember silicon and offering a simple and fast way to develop a ZigBee wireless system. The ETRX2 firmware is based on the EmberZnet stack and performs all mesh-networking functions such as network forming, data retransmission, self - healing and route discovery.

One advantage of Telegesis products is that two versions of the module are delivered with the same form factor - a low cost base ETRX2 module and an ETRX2-PA module with an additional 100mW amplifier allowing designers to optimize the overall cost of the system.

*From initial concept stage the TBN system has been designed to be truly scalable .*

Typically, Modules without amplifiers have an outdoor range up to 300 m however experience showed in the installation of the Moscow water meters that the ETRX2 modules can reliably transmit messages from inside an apartment with a metal door to a stair well platform. The more powerful ETRX2-PA modules allow outdoor data transmission typically, up to 800 m, and can transmit data over 3-5 floors inside an apartment block.

Module configuration is performed by programming internal non-volatile registers. All modems in a network are the same and can be assigned as a coordinator, router or end device. The Telegesis AT-command set introduces an additional concept – a central acquisition data node known as a 'sink node' which is assigned by programming a corresponding modem configuration register. The co-ordinator or any router in a network can be assigned as a sink. An important advantage of Telegesis ETRX2 modules is a deep sleep mode giving current consumption of less than 1µA whilst the RTC continues to work allowing thereby allowing end nodes to extend their battery life to several years.

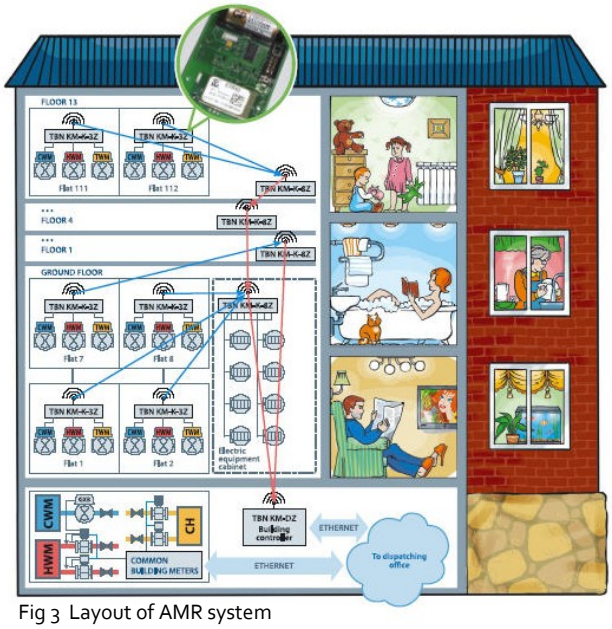


Fig 3 Layout of AMR system

A unique 64-bit identifier pre-programmed into each module at manufacture is used for node addressing and the availability of embedded firmware tested by the manufacturer reduces system development time and eliminates the need for expensive, complex development tools. The Telegesis AT-command set supports comprehensive functions including wireless network forming, network monitoring, transmit/ receive messages via radio channel, input/output of digital and analog information, and control of timers and serial interface. Thus designers using ETRX2 Modules can concentrate on application tasks and simply treat the wireless network as an easily implemented data transmission interface.

**Ember Corporation mesh networking technology**

All Telegesis modules are built around ZigBee technology from Ember Corporation. Ember's ZigBee Stacks enable large, dense, networks with excellent mobile capabilities and give secure and resilient ZigBee Networks with excellent power savings. Software stacks such as EmberZNet PRO 3.1 and later, delivers robust and reliable mesh networking, supporting all ZigBee device types in a single stack image for Ember's IC platforms.


Fig 4. TBN logger

EmberZnet PRO 3.1 includes the industry's first proven stack based on the ZigBee PRO Feature Set, enhanced with Ember innovations; it provides many features for challenging applications

ZigBee PRO adds many new advantages including larger networks scaling to potentially thousands of nodes in a single network enabled `by Stochastic Addressing, Many-to- One/Source Routing and Asymmetric Link Handling. Dense networks through intelligent table management assure network stability even when many routing nodes are within close proximity. network to change channels when interference is present

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Configurable deep-sleep time-outs and special router parent functions significantly extend battery life of end devices by allowing networks capable of sleep and hibernation. Security is further enhanced by implementing many of the optional ZigBeePRO security extensions for advanced network encryption and device security. Resilient networks are also assured by a frequency agility feature allowing the entire the entire network to change channels when interference is present .

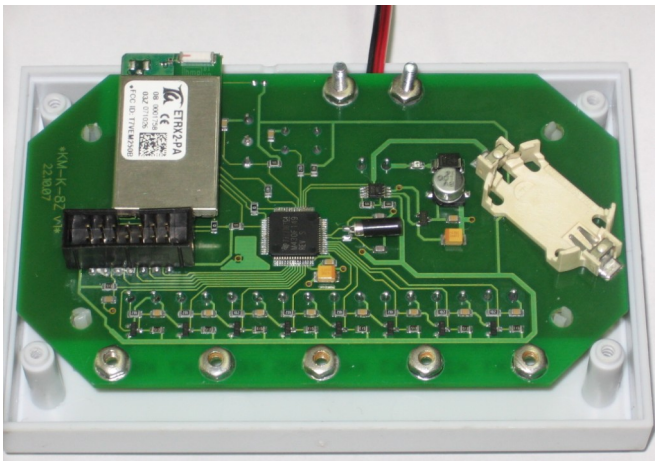


Fig 5 Floor controller

**Main Blocks of TBN Wireless Automated Water Meter Reading Subsystem**

The main block layout of the TBN Wireless Automated Water Meter Reading Subsystem is shown in Fig. 3. In this scheme apartments are equipped with TBN KM-K-3Z loggers (Fig. 4), which have inputs for three meters – one each for cold and hot running water and one for heated water used for central heating. TBN KM-K-3Z loggers include a microcontroller and an ETRX2 module and are configured as sleepy end devices in the wireless network.

Floor controllers KM-K-8Z (Fig.5) are located on stair landings of every floor in built-in cabinets with electricity equipment. They are mains powered and are configured as routers in the ZigBee wireless network. In addition, each KM-K-8Z has eight inputs for electricity meters with impulse output. In most cases the electricity meters are in the same electricity cabinet. Floor controllers KM-K-8Z have microcontrollers and an ETRX2-PA module which has additional power amplification enabling data to be transmitted over 3-5 floors.

The Building controller TBN KM-DZ (fig.6) is based on an ETRX2-PA amplified module which is pre-programmed to work as a network sink node. All information from network routers is sent to a TBN KM-DZ which communicates to a dispatcher office via Ethernet. In addition the building controller KM-DZ has an additional USB port allowing collected information to be copied into a USB flash stick if needed. The building controller has no visual display, so in order to read the system state a removable operator panel KM, with a 4-line alphanumeric LCD and a small keyboard is used allowing TBN KM-DZ memory reading and monitoring of network node states.

There is also an independent metering system inside the building based on existing water meters. Information from this system is also transmitted to a dispatching office via Ethernet.

**System commissioning and operation**

The major advantage of this system is its commissioning simplicity. KM-K-3Z loggers are installed in apartments at the same time as water meters (fig. 7) and no additional power or signal cables are needed. Installation engineers simply mark the locations of every node on a building plan and fit node identifiers. Floor routers are installed in built-in cabinets on each landing where mains power is available (fig. 8). The Building controller TBN KM-DZ (fig.9) is placed either in a basement or an attic or roof space.

Immediately after installation, end nodes and routers begin joining the network. They perform a 'PAN SCAN' and attempt to join the established wireless network. When the central sink node is switched on routers connect to it and end nodes link to the routers. During network building only nodes with a pre-programmed encryption key are permitted to join. A unique 64-bit identifier pre-programmed into each module at manufacture is used for node addressing.
Child nodes choose their parents randomly. Parent routers could be situated either on the same floor as their children or on upper or lower floors. End node messages contain specific identifiers which allow a central node to correlate data received via intermediate routers with apartment numbers.

# AMR AND AMI SOLUTIONS USING ZIGBEE

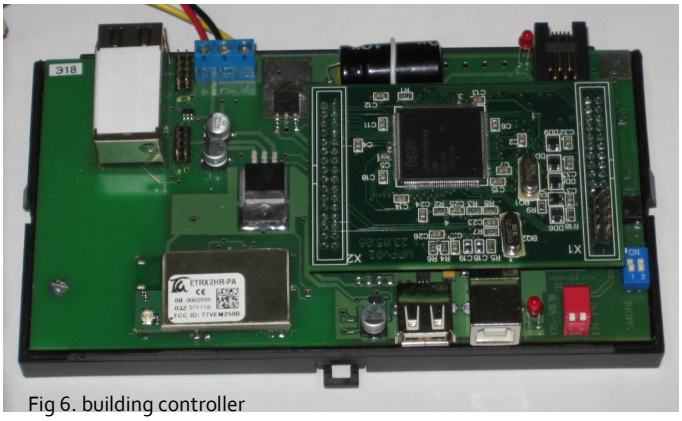

Fig 6. building controller

*The major advantage of this system is its commissioning simplicity.*

Fig 7. KM-k-3Z Logger

It's calculated that end nodes can work for up to 4 years on one set of batteries. In order to save battery power the KM-K-3Z end nodes transmit data to their parent routers once per hour. The receiving routers then buffer this data. Whilst in communication with end nodes, routers synchronize the end node clocks and transmit any relevant control information from the central node if required. When routers perform data exchange with their child node loggers in each apartment, data is not automatically retransmitted. These exchanges are simply data acquisitions in multiple independent star configuration networks distributed throughout the building with the routers working as central nodes of the stars.

Routers only transmit all buffered data upon a request from a central sink node. At this stage a wireless mesh network mechanism with retransmissions and route discovering is applied. Installing routers on every floor provides several possible routes for message transmission to the central node. In this case a wireless network can automatically choose the optimal route and rediscover a new route in case of failure of the old one.

The GIS TBN ENERGO system has distributed intelligence. Each level is responsible for its own data processing task. So end apartment loggers KM-K-3Z have buffers that permanently contain data reflecting the cumulative total of water consumed since last meter calibration. End nodes also calculate the value of consumed water, control meter link quality, monitor meter cover state (open/closed), report on battery status and other possible problem states.

Floor routers KM-K-8Z add additional data from their local electricity meters to these messages before forwarding them.
The central building controller KM-DZ aggregates data to a dispatching office. This office also receives information from independent, existing building meters and comparing results from these two information sources, calculates a balance of water consumption in a building alerting authorities to possible leaks and equipment failures. As end loggers permanently store cumulative records of total consumed water there is no risk of information loss even if communication between an end node and the whole system is lost. If an end KM -K-3Z logger loses contact with a parent router it will continue counting water consumption and calculating the water consumption tariff while the information system informs the authorities that there is a loss of contact with that end node. After communication is re-established the end node will transmit all the data collected whilst it was out of contact. Thus TBN Energoservice Company has developed an easy to install, reliable automated meter reading systems of up to 500 water meters.

Consumers in each apartment can be sure that they are being accurately billed granting them sight of their consumption levels and enabling them to monitor and conserve water usage. Utility companies benefit from accurate customer consumption figures improving billing and payment collection with a consequent reduction in bad debts and unpaid bills. The technology also assists by detecting leaks and equipment failure far more quickly than usual. All the above gives a very ecological solution for water usage and reduced energy consumption through the efficiency of the ZigBee wireless metering system

Fig 8. Floor router

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About Telegesis
Telegesis is a specialist provider of ZigBee module technology based in Marlow UK. Telegesis modules enable companies to design in ZigBee PRO wireless capability without the need for specialist RF or embedded firmware capability. This reduces cost and risk for the design engineer whilst getting the wireless solution to market faster. Telegesis is a Participant Member of the ZigBee Alliance.
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About Ember Corporation
Ember Corporation develops ZigBee wireless networking technology that enables companies involved in energy technologies to help make buildings and homes smarter, consume less energy, operate more efficiently, whilst keeping people comfortable and safe. Ember's low-power wireless technology can be embedded into a wide variety of devices to be part of a self-organizing mesh network. Ember is headquartered in Boston and has its radio development centre in Cambridge, England. The company is a promoter and Board member of the ZigBee Alliance and its platform is the "Golden Suite" for 802.15.4/ZigBee interoperability testing.
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