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WIRELESS M2M SYSTEM ARCHITECTURE FOR DATA ACQUISITION AND CONTROL

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Abstract. *The high technological advance in the field of communication and computation allows a new form of machine interconnectivity- wireless M2M technology. The article presents solution for distributed wireless M2M system architecture for data acquisition and control. Some system's applications have been reviewed.*

The system has hierarchy structure including tree types of modules are specialized in data collecting, analysis and control and communication management.

The data collecting modules provides measure of different physical parameters and supports wireless and wired communication interfaces.

The control module change actuators parameters regarding the data measurement it received by data collecting modules and selected control strategy. Communication modules provide possibility of localized monitoring, analysis and control of the system via Internet and cooperation to other M2M stations

The system supports Bluetooth & Zig Bee to GPRS gateway capabilities.

1. INTRODUCTION

The recent convergence of Internet and wireless communications become a premise for advent of wireless M2M (mobile to machine, machine to mobile) technology. It is a generic name for emerging third generation of computing – Post PC generation. This third generation involves low-cost, scalable and reliable inter-machine (systems with mechanical, electrical or electronics characteristics) interaction via wireless communication standards like GSM/GPRS ,IEEE 802.11, Bluetooth (supports communication links between devices on short distances), IEEE 802.15.4 (used for low speed data transfer between low-power consummation devices) [1].

M2M allows a wide variety of machines to become nodes of personal wireless networks, global Internet which provides to develop monitoring and remote control applications. This will decrease costs for involved human resources and will make machines more intelligent and autonomous. Wireless M2M technology brings in new direction the state of development of the systems for data acquisition and control. The systems are not only passive data collecting modules which delivers sensed data to some central machine for analysis and data processing in some proprietary network, something more systems getting more and more autonomous in decision making for control and in Inter-machine coordination.

Although the technology is in its beginning market analytics predicts its success taking into consideration the fact that in the year 2010 there will be over 1 billion mobile devices

supporting M2M connectivity. The M2M systems can interface with virtually any type of mechanical, electrical or electronic system for an unlimited number of specific applications, including:

- Access control and security
- Vehicle tracking systems
- Home automation systems
- Automotive systems
- Robotics
- Medical systems

This paper presents a suggestion for design and implementation of Wireless M2M system for data acquisition and control (Data Collection and Control Virtual Network-DCCVN). The design integrates data collection module, control module, and communication (gateway) module. Detailed description of each system design component's functionality and structure are presented.

2. SYSTEM CHARACTERISTICS AND ARCHITECTURE

2.1 System Characteristics

Wireless M2M system for data-acquisition and control belongs to the class of distributed, heterogeneous, network systems for data collecting, data processing and process control. It provides following features:

- Remote data monitoring and control of subsystems via global Internet network
- Dynamic configuration and software update of system modules via Internet
- Communication and control interfaces to industrial microcontrollers integrated into machine network system
- Possibilities for building data acquisition tracking systems
- Cooperative task processing and evaluations between subsystems.
- Possibility for generation and processing of parametric query to distributed databases.
- Support of useful component based software framework
- Building of heterogeneous networks based on wireless and wired communication technologies
- Service of different type of embedded devices using wireless and wired interfaces

2.2. System Architecture

The system is designed as hierarchy structure of components which services control and data collecting tasks via wired and wireless interfaces. It includes a set of subsystems described in the next points.

2.2.1 Operation Station (OS)

Operation station is realized as standard computer configuration connected to the Internet The system software includes custom tools for end user access to the DCCVN abilities. The operation station will be realized on the advanced platforms as Windows XP, Linux using NET framework.

2.2.2 Data Collecting Module (DCM)

Data collecting modules include a number of smart nodes (SN) forming Bluetooth or ZigBee wireless networks. The modules realize functions of the interaction of the DCCVN with the external environment. Each of them provides possibilities for data collection of the measured physical parameters based on dynamically adaptive or fixed algorithmic scheme.

The data collecting adaptive schemes takes into account the current power consumption status of the nodes, network bandwidth load and applies different algorithms for their reduction. The addressing scheme could be context aware or address based on whether module is running in admin mode or in data acquisition mode.

2.2.2.1 Smart Node (SN)

Smart nodes form Bluetooth piconets [2] or ZigBee networks used for coordination and transmission of the collected data to the Gateway. Each of the smart nodes consists of sensor, communication and processing units.

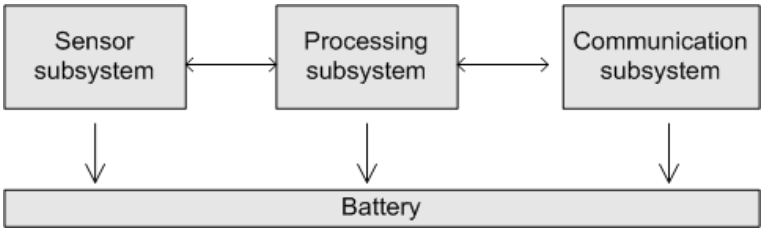

Fig. 1.Schematic presentation of Smart node architecture.

Bluetooth smart nodes offer the following features:

- Communication subsystem - provides communication via Bluetooth RFCOMM protocol with other devices, forming Bluetooth piconets[3]. The Bluetooth protocol stack is implemented in KC-11 Bluetooth micromodule. It integrates arm-7 microprocessor and antenna which provides Bluetooth serial cable replacement profile. The micro module provides up to 723 kb/s data-rate and up to 300 m communication range. Due to possibility of forming more complex networks – scatternet this communication range could extend to kms. Bluetooth micromodule schemes are optimized to work in low power consumption mode. Each Bluetooth micromodule could be controlled by processing subsystem using custom AT command set. The hardware interface between the micromodule and processing subsystem is realized with UART port of processor unit. Radio data transmission is based on external or chip antennas.
- Processing subsystem-It is based on low power consumption RISC microcontroller. The subsystem realizes coordination tasks for service of other subsystems under the control of DiOS. Important role for node battery long life and support of all nodes' activities play the specialized software responsible for optimal consumption control.
- Sensor subsystem – Includes passive sensors for measurement of different physical values–temperature, humidity, light. They vary in functionality depending of the user case scenario. Processing subsystem interface with sensor subsystem via ADC, or input output digital channels, realized into the microcontroller.
- Battery power provides all subsystems functions. Usually it is accomplished as accumulator block and is controlled by processing subsystem.

ZigBee [1] smart node applies the same system features as Bluetooth smart node.
It is specified with the following differences:

- Its communication and processing subsystems are integrated in single chip solution Jenic wireless microcontroller. It integrates 16MHz 32-bit RISC optimized for low power (3MIPS/mA) processor, 2.4 GHz IEEE802.15.4 transceiver and incorporates wide range of digital and analog peripherals to interface with sensor subsystem. It realizes ROM resident IEEE802.15.4 communication stack and provides ZigBee star,

tree, mesh network of devices located at maximum distance of 1 km up to 250 kb/s data rates.

- Low-level software libraries are provided for control of node peripherals and communication flow. There are capabilities for software design of upper level user applications.

2.2.3 Gateway

Gateway module provides control and localization services for data collecting and industrial controllers included in machine network .It supports Bluetooth, Zig Bee, GPRS, GPS gateway capabilities.

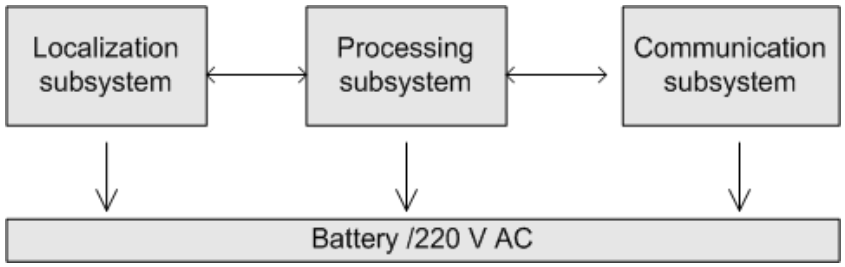

Fig 2.Schematic representation of Gateway architecture

Gateway module main design components are as follows:

- Communication subsystem –provides Bluetooth, ZigBee, GPRS interface to service Data collecting module and transmit collected data to operation using Internet infrastructure. The subsystem has full-duplex communication with remote station for control and parameter configuration. The module main components are KC-11 Bluetooth micromodule with external antenna, Jennic wireless module for ZigBee communication and “TelIt” GPRS/GPS embedded modem. All communication modules are controlled by RISK microcontroller.
- Processing subsystem- It is based on Atmega 2560 microcontroller [5]. It integrates 8-bit RISC kernel, 256K Flash and a number of peripheral units. It controls Communication subsystem units via four UART ports in interrupt driven mode. One of the ports is designed for interface with industrial microcontroller “Octoport” using RS232 or USB interfaces.

  The subsystem includes 512K external memory used for local data store.

  Real time OS-resident in processor flash is responsible for service of communication protocols, peripheral protocols, low power task scheduling algorithms, OS updates, records to system store.
- Localization subsystem -- provides communication to GPS system in order to provide precise location and timing information. It is designed in Telit GPRS/GPS micromodule [4] which supports up to 20 GPS channels and NMEA data format. Processing subsystem controls GPS micromodule via UART interface.

2.2.4 ”Octoport” Industrial Controller

Octoport industrial controller [6] is designed for realization of gateway between different industrial wired networks .Additional feature of its implementation is the possibility for communication with wireless devices via Bluetooth or ZigBee interfaces.

Octoport supports 8 independent 1-Wire busses, RS 485/422 industrial buss, RS232/USB, Bluetooth, ZigBee.

The module integrates ATmega 128 as host processor, external 256 k energy independent memory, Real Time clock calendar, LCD indicator for operation status, four optoisolated input output for direct control. The module includes block for control and recharge of accumulator battery. The system software includes number of drivers for different communication protocols, peripheral devices drivers.

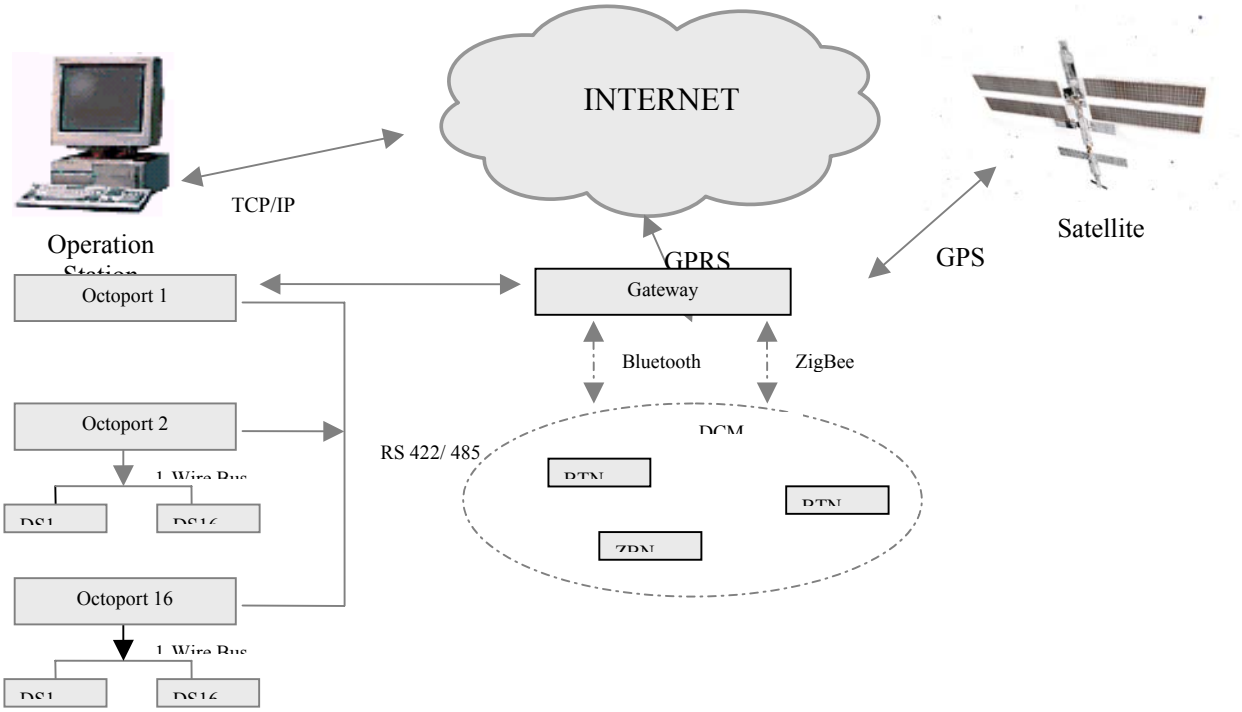

Fig. 3 Architecture of DCCVN

3. CONCLUSION

The suggested system architecture gives possibilities for building more intelligent and autonomous wireless M2M system. It resolves communication and control problems between different in technical characteristics machines and make them part of global Internet network. The provided generic software framework allows systems to function in different application domains.

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