REWINS

Reconfigurable Wireless Interface for Networking Sensors

Abstract

Remote Monitor & Control systems are increasingly being used in biomedical, chemical, engineering, security, transportation, manufacturing, supply chain, healthcare, etc. In this research, attempt is to develop a solution of wireless monitoring and control for such industrial scenarios. The solution is built on two components – a generic reconfigurable wireless interface for remote data collection-actuation units and control architecture at the central control unit (CCU) for smart data processing. The data collection/actuation unit (sensors-actuators-controllers) is made intelligent by virtue of a smart-wireless interface, which is reconfigurable using the Over-the-Air (OTA) paradigm. The RF link as well as the interface-firmware is reconfigurable to accommodate a variety of RF modules (Zigbee, Bluetooth, 802.11 or RFID) and sensors/actuators/controllers. The control architecture supports services such as naming, localization etc., and is based on JavaBeans, which allows a component level description of the system to be maintained, providing flexibility for implementing complex systems.

REWINS motivation

The current generation automation systems, control & monitoring systems, security systems, etc., all have the capability to share information over the network and are being increasingly employed to aid real-time decision support. The inter-device communication in such systems can be leveraged to maximize the efficiency and convenience in a variety of situations. Intelligent wireless sensors based controls have gained significant attention due to their flexibility, compactness and ease of use in remote unattended locations and conditions. These wireless sensor modules can be designed to combine sensing, provide in-situ computation, and contact-less communication into a single, compact device, providing ease in deployment, operation and maintenance. Already large-scale wireless sensor networks having different capabilities are being used to monitor real-time application needs.

"...to provide a single comprehensive architecture to support the diverse control automation needs of a variety of industrial applications"

Different types of sensors (thermal, photo, magneto, pressure, accelerometers, gyros, etc.) having different capabilities, interfaces and supporting different protocols are used for different applications. For remote data collection, RF communication links with different characteristics, such as frequencies, data carrying capacity, bandwidth, susceptibility to interference, power needs, etc., have been employed to transmit the data. The appropriate design of the wireless sensing device depends on the end application needs such as data bandwidth, range, interference, etc.

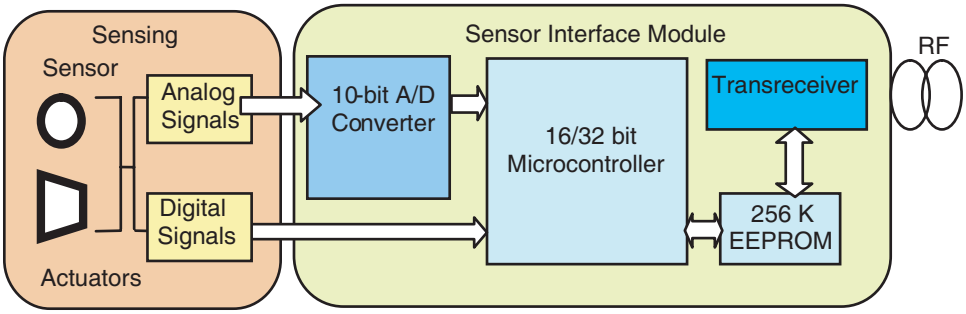
"... can be designed to combine sensing, provide in-situ computation, and contact-less communication into a single, compact device, providing ease in deployment, operation and maintenance."

In the proposed work the attempt is to provide a single comprehensive architecture to support the diverse control automation needs of a variety of industrial applications. The data collection/actuation units will be made intelligent by equipping them with smart microcontroller based wireless interface. Utilizing the plug-n-play modularity of the system architecture, appropriate sensor interfaces and RF communication interfaces can be chosen according to the application requirements. Further, once the interfaces are chosen, the (developed) application interface could be used to implement the specifics like description, placement, interaction of sensors and actuators, etc. For example; the interaction could be a "closed loop" control of a motor where the sensor is an encoder and actuator a motor.

REWINS system

Wireless Node

This node will interface with the sensors on one and end and wireless interface on other end. This element helps the data collection and transmittal at the last mile. The node is "generic", i.e. it accommodates variety of sensors on one end and interfaces with different wireless interfaces on other end. In the current system, the wireless node is implemented using a microprocessor-based system and reconfiguration is restricted to a certain functional level (firmware modification). A schematic of the system is shown in figure below:



Hardware design of the smart wireless interface

Application Integration Platform

The Application Integration platform resides in the Central Control Unit and helps building systems and sub-systems of the sensors, actuators and controllers. The control architecture is based on Javabeans API and hence enables visual integration of various components (sensors/actuators and controllers) to form complex systems. The integration is hierarchical but modular. This also enhances the overall plug-n-play functionality of the entire system.

Future work entails extension of the system to provide a full fledged reconfiguration support by using a complete Software-defined radio (SDR)/processor based implementation. The new platform will help port extensive services like reliability, security, interference management, required for remote monitor and control systems.

Features

The features of the current system include:

1 Reconfigurability: Central Control Unit can set the run-time parameters of the device and/or update/upgrade the firmware of the system over the air (OTA).

2 Plug-n-play: Depending on the application needs/requirements, different infrastructure and their configurations can be deployed quickly.

3 Self-calibration: the intelligent adaptive sensors can accurately measure data and self-calibrate without significant user intervention.

4 Wireless connectivity: provide bi-directional communication over a wireless connection.

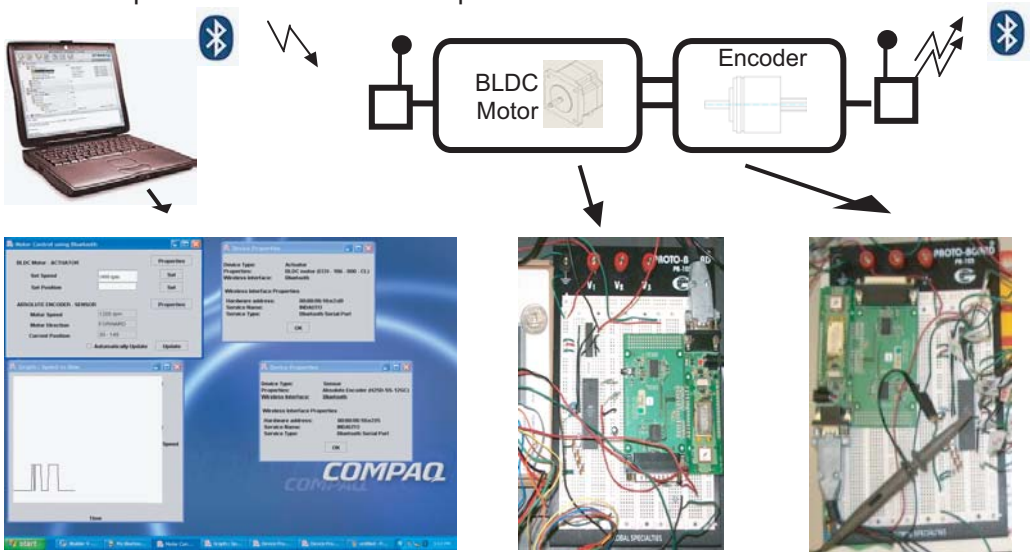
5 Lower installation and maintenance cost: no wiring/cables, etc., is required and therefore enabling greater acceptance and speedy deployment.

REWINS sample applications

The ReWINS system can be used for scalable, efficient, resources-aware data collection, aggregation and processing tasks. The ReWINS system thus finds application in variety of areas. Some specific application scenarios are given below:

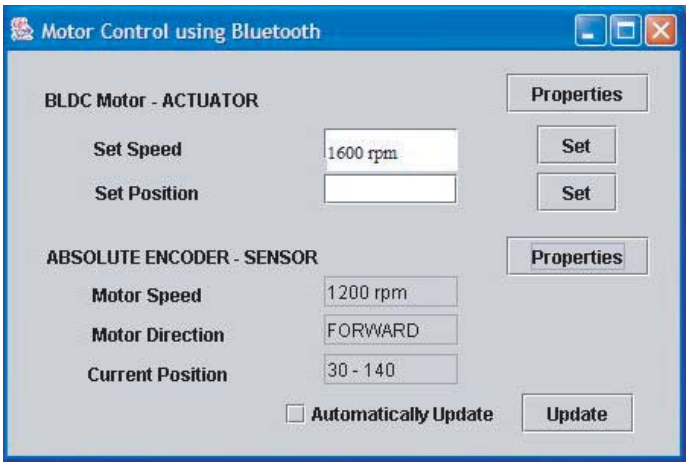
1) Industrial Automation Applications
   a. Health Monitoring Systems
   b. Motion Control Systems
   c. Instrumentation Systems
2) M2M Applications – Remote Data Monitoring for Utility Industries
   a. Energy Distribution Systems, for e.g. remote meter reading
   b. Health Maintenance Systems, for e.g. pipeline monitoring

Some snapshots of the current implementation are shown below:

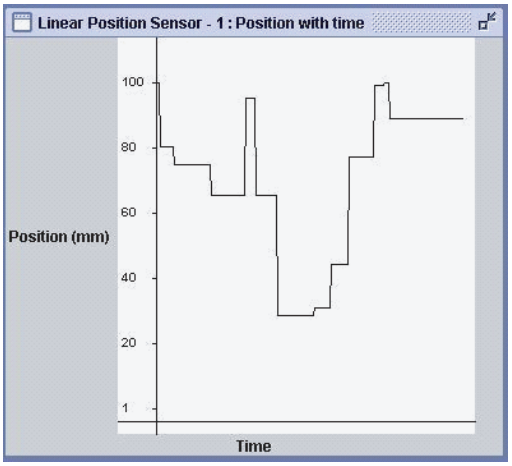


Control Interface at the CCU | Actuator | Sensor Interface

Closed-loop control implementation using ReWINS



Control Interface Window at the CCU



Output graph at the Central Control