Intelligent Bridge Health Monitoring System

INTRODUCTION

An effective structural health monitoring system is using a minimum number of sensors to evaluate the health status of a bridge and archiving minimum amount of data to reflect the history of the bridge. Intelligent Bridge Health Monitoring System (IBHMS) is an ideal system to achieve these goals by using advanced sensor technology and bridge intelligent analysis and evaluation technology to detect the bridge damage and evaluate the bridge health status.

IBHMS is developed for monitoring the health status of a bridge in real time remotely. It is the integration of sensor technologies, data acquisition and processing, communication network and computer technology. Once the system is installed to a bridge, the owner can monitor, analyze and evaluate the bridge upon accessing the data from the entire sensors, and or the sensors at specific locations on the bridge at any time and any places through the Internet.

- The target of the IBHMS is to provide the safety and serviceability information of bridges to bridge authority. The information in history, present, and the prediction are provided.

- IBHMS is a platform, which is designed to remotely monitor and analyze the current condition of any bridges in real time and in a long run as well. It is an open system in hardwarewise and softwarewise.

- IBHMS is based on Substation/ Server/ Client infrastructure. A redundant communication network, consisting fiber optic link and wireless mesh network, is adopted to guarantee the data can be collect by the central server during any severe event.

- Open system – The system is a platform. Servers, Substation and sensors can be freely added and removed from the system. Data in the system data base can be retrieved for third party software such as Finite Element Analysis Software.

- Distributed system – Servers, substations and clients can be located at any place connected by the internet. Each unit performs certain tasks, so the server's workload can be reduced.

- Customizable – For each individual application, the system can be customized in area of data processing methods, reporting methods, warning criteria, data backup strategy, and system maintenance procedures.

- User friendly – The client-side software gives users abundant flexibility to compose their personal display contents and layout styles.

PRINCIPLE of IBHMS

Figure 1 is the block diagram of an intelligent bridge health monitoring system. It consists of a system server, substations and the network connecting the system server and each sensor station. The monitoring system has four warnings. They are individual sensor warning, local area warning, structure member warning and bridge warning. Each warning has three levels. In this system, the data processing and analysis will be implemented in both the system server and each sensor station attached to the system. The data processing in sensor station will focus on data pre-processing and primary warning makings. However, data processing in system server will concentrate on data post-processing, data analysis, structure evaluation, bridge health assessment and critical warnings. The system is an Internet based multi-user system that authorized customer may access each database. For a long-term monitoring application, a redundant system can guarantee the structure damage information send to the central server during especially in a catastrophe event. IBHMS has a LAN by using an Ethernet whose nodes are interconnected via twisted pair cables or fiber optic link. Using wireless in ISM band or commercial wireless network serves as a redundant communication channel.

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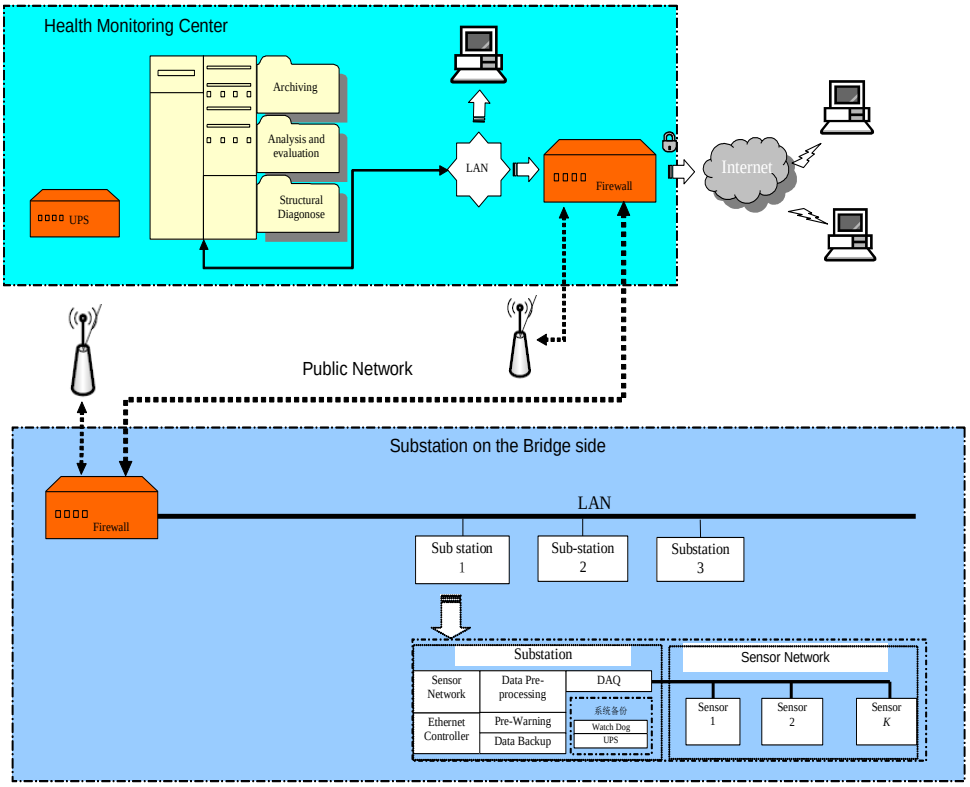

Figure 1. Schematic diagram of distributed intelligent bridge monitoring system

SYSTEM SERVER

The system server includes network control, data processing and archiving, databases, bridge intelligent diagnose and expert system as well as customer service platform. The monitoring system is an Internet based system. The software platform is a Windows-based platform. While collecting all data from the sensors installed on the bridge under monitoring through each individual sensor station by way of sensor network, it pre-process and archives them with respect to the sizes and types of structures and sensor type and its location. The bridge export system or intelligent diagnose system will evaluate the health status of the structures and the bridge itself through data from all sensors. Multi-user software platform allows customer to access to database of the bridge through Internet network. By way of the server, the customer can locate any individual sensor placed on the bridge. The system has the following functions but not limited:

- Display sensors' data in real-time and the data in databases,
- Pre and post-process data
- Data processing parameters and methods amendable
- Database and hardware expandable
- Easy interface for additional software module plug-in
- Advanced structure and bridge warning system
- Intelligent Bridge diagnose and evaluation system.

The system has resourceful databases such as design parameter database reflecting the design of a bridge, original parameter database reflecting the construction of the bridge, original data database, long-term data database, system data database for system operating and warning criteria database. These databases allow customers to trace the health history of the bridge, understand the structure and bridge and choose the optimism data processing method and parameters. Many necessary analysis tools are embedded into the system software, including digital signal processing

tools, statistic analysis tools, and structural evaluation tools and so on. Moreover, two high level warnings will generate when the data of structure member or bridge pass over the threshold. The system will provide bridge health report regularly with regard to the status of the bridge in percent and the past.

SUBSTATION

A substation consists of a single board computer including DAQ, interfaces such as Ethernet, RS232, RS485/422, USB, RAM and Flash memory, and system expansion interface. It functions as DAQ and data pre-processing processing unit that collects the data from all the sensors attached, synchronizes and validate the data using digital signal processing method. In the mean time, it will generate two warnings: sensor warning while any signal overpasses its thresholds and local area warning while the values from several related sensors at a location pass over their thresholds. Moreover, it may work as a Data logger when power supply and or network fail. The substation will be placed on the bridge site. Therefore, it has low power consumption, no moving parts and large enough storage to buffer data collected in case of power or network failure. The specifications of the system are as follow:

- VIA 733 MHz low power C3 processor C3 processors have extremely low power dissipation which allows fanless operation making it ideal for industrial applications.
- 32 to 512MB of system PC133 SDRAM supported in a 144-pin SODIMM socket
- Socket for up to 1GB bootable DiskOnChip®
- Type I and II Compact Flash (CF) cards supported
- PC-compatible supports Linux, Windows CE.NET and XPe, plus other x86-compatible RTOS
- 10/100 Mbps Intel PCI Ethernet controller
- 4 RS-232 serial ports with FIFO, COM1 & COM2 with optional RS-422/485 support
- Bi-directional LPT port supports EPP/ECP
- Two USB 2.0 ports onboard
- Up to 2 minute reset on watch dog timer
- 16-bit A/D subsystem
- 16 single ended or 8 differential input channels
- Sample and hold supported
- Input ranges: 0-5V, ±10V
- All input channels protected to ±30V
- 33 KHz throughput
- Operates in Polled Mode or Interrupt at end-of-conversion
- Low power and low cost
- Support 5B series signal conditioner.
- Interface for Geokon® dynamic vibrating wire gauge sensor.
- -40°C to +85°C operating temperature

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