A feasibility study of a high-resolution digital image distributed surveillance system over a Zigbee network

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***Abstract*—This work-in-progress paper briefly describes the approach for testing the feasibility of a surveillance system using high-resolution digital images (instead of lower resolution video streaming) using IEEE 802.15.4 (Zigbee) as transport medium. A higher resolution digital image contains more data, which is beneficial to security systems and can be used in facial recognition systems. A proof-of-concept will be developed and tested. The bandwidth constraint imposed by the low-power Zigbee protocol is the research area to be explored in this project.**

I. Introduction

With the rapidly growing market for short range wireless communication systems, the support of security and surveillance related applications over sensor networks are becoming important. IEEE 802.15.4 (Zigbee) is not well suited for real time applications, because it doesn't offer high data rates. The cost of a wireless surveillance system will be lowered if IEEE 802.15.4 based devices are used. The collaborative nature of Wireless Sensor Networks (WSNs) brings several advantages over traditional sensing including mobility, greater fault tolerance, improved accuracy and larger coverage areas.

A wireless sensor network (WSN) is a computer network consisting of spatially distributed autonomous devices originally designed for using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollutants, at different locations [1]. Most of the attention on wireless standards, i.e. IEEE 802.11 and cellular networks, focus on high rate and long range applications. However, some new WPAN (Wireless Personal Area Network) standards were developed for low rate and low cost set of applications. IEEE 802.15.4 is a standard for low rate wireless personal area networks (LR-WPANs) which is designed for low cost, low power and short range communications. Many challenges limit the design of an efficient surveillance system in wireless sensor networks. Some of the challenges are caused by resource limitations such as limited power and processing capability and the error resilience capability of video compression techniques (streaming video surveillance). In addition, the capacity and throughput provided by wireless channels is low because of the path loss, fading and interference.

In general, IEEE 802.11, Bluetooth and other technologies are more suitable for real time applications than IEEE 802.15.4 since they offer much higher data rates. Zigbee wireless mesh-networks are low data rate networks that implement the IEEE 802.15.4 as their physical and MAC layers. Technologies such as Bluetooth do not allow for mesh-networking and only operates on the client-slave model with very limited piconet interconnections [2].

The purpose of the proposed research is to investigate the feasibility of a high-resolution digital image distributed surveillance systems ([3], [4], [5]) using IEEE 802.15.4 (Zigbee) as transport medium. The research will focus on maximizing the throughput provided by the wireless channels and provide high-resolution images for surveillance systems.

II. Design

The functional block diagram for the design can be found in Figure 1. The system consists of three functional parts: a camera module (including motion sensor), the communication medium and the server side processing.

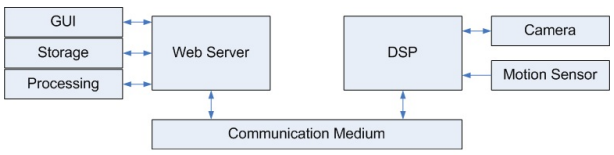

Fig. 1. Functional Block Diagram of proposed research

A. Proof-of-concept

A LAN (local area network) based surveillance system will be implemented (a high-speed wired network will replace the proposed low-speed Zigbee link). Motion sensors should detect intruders and a camera module will take a high-resolution pictures - the pictures will then be transferred via the wired link to a PC. This serves as a proof-of-concept for a high-resolution digital image distributed surveillance system employing a non-restricted bandwidth solution.

B. Research

IEEE 802.15.4 defines the physical layer and the MAC sublayer of the OSI Zigbee layers. It supports devices that consume minimum energy and is designed for low rate, low cost applications over a short range of 30 to 100 meters. Zigbee has dual frequencies 868/915 MHz and 2.4GHz. The 2.4GHz ISM frequency is the same band as IEEE 802.11b, g, n, IEEE 802.15.1 and microwaves. Zigbee's technology is slower than 802.11b, g, n, but it consumes less power. A total of 27 channels with three different data rates are defined for the IEEE 802.15.4: 16 channels with a data rate of 250 kbps at the 2.4 GHz band, 10 channels with a data rate of 40 kbps at the 915 MHz band, and 1 channel with a data rate of 20 kbps at the 868 MHz band.

The research conducted will focus on maximizing the throughput of the Zigbee network based on bulk data transfers. The parameters for inspection to research the throughput efficiency: single/multi-hop mesh networks, radio interference, distance propagation, multiple camera input-sources (timing aspects, segmented transfers) and network implementation (coordinator placement, route redundancy)

C. Hardware

Camera module - The Leopardboard is a full featured, ultra low cost, small form factor, high performance development system which includes TMS320DM355 Processor board and a VGA camera board to provide VGA resolution video capture. DM355 combines high performance MPEG4 HD (720p) codecs and JPEG codecs up to 50M pixels per second, high quality, and low power consumption at a very low price point.

Zigbee development kit - The CC2430 is a true System-on-Chip (SoC) solution specifically tailored for IEEE 802.15.4 and Zigbee applications. It enables Zigbee nodes to be built with very low total bill-of-material costs. The CC2430 combines the excellent performance of the leading CC2420 RF transceiver with an industry-standard enhanced 8051 MCU, 32/64/128 KB flash memory, 8 KB RAM and many other powerful features. Combined with the industry leading Zigbee protocol stack (Z-Stack) from Texas Instruments, the CC2430 provides the market's most competitive Zigbee solution.

III. Contribution

The approach for the research into the feasibility study of a high-resolution digital image distributed surveillance system using a Zigbee network is described in this work-in-progress. The proposed study is to provide a proof-of-concept system, by removing the bandwidth restricted Zigbee connection and replacing it with a high-bandwidth wired Ethernet connection. Further research (design, simulation and implementation) into the use of a Zigbee network for bulk file transfers will be concluded to determine the feasibility of the complete system.

The use of high-resolution digital images could hold certain benefits from current video streaming options. Most CCTV systems operate on continuous 648x488 pixels resolution (0.3 MP) video feeds; the ability to employ resolutions of up to 5MP (megapixel) for surveillance using still images can provide improved object identification/classification due to the increased information present.

The successful completion of this research will result in the ability to consider high-resolution digital images as an input source for a localized distributed surveillance system and the ability to employ Zigbee networks for the specified application. The mobility and low price point of such a surveillance system should generate more interest in this research field.

Progress - A literature study has been done on the appropriate technologies (focusing on Wireless Sensor Networks and Distributed Surveillance systems). The hardware-selection design phase has been completed and the hardware specified in Section II-C have been obtained. The author is currently in the process of developing the required modules needed for the proof-of-concept design and the IEEE 802.15.4 (Zigbee) throughput research.

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