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A Survey on Energy Consumption and Control in Wireless Network Control System

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ABSTRACT
In wireless sensor networks (WSNs) nodes often operate unattended in a collaborative manner to perform some tasks. In many applications, the network is deployed in harsh environments such as battlefield where the nodes are susceptible to damage. In addition, nodes may fail due to energy depletion and breakdown in the onboard electronics. The generalization comprises a wide range of objective functions including total power consumption of the network, maximum power consumption among the nodes in the network and log-sum of the power consumptions of the nodes in the network, any modulation scheme and any scheduling algorithm. In this article we presents the various scheme related to energy management in wireless networked control systems, here we defined the comparative study for the energy management in wireless sensor networks.

Keywords: Wireless sensor-actuator networks, Wireless networked control systems, Quality of services, Wireless sensor networks.

INTRODUCTION

Wireless sensor-actuator networks (WSANs) are gaining rapid adoption in process industries due to their advantage in lowering deployment effort in harsh industrial environments. Industrial standard organizations such as ISA, HART, WINA, and Zig Bee have been actively pushing the application of wireless technologies in industrial automation and manufacturing. While early success of industrial WSANs focused on monitoring applications, there is significant value in exploring WSANs for process control applications to take full advantage of wireless technology in industrial plants [10]. Wireless networked control systems (WNCSs), in which physical elements (plants, sensors, controllers, and actuators) communicate via wireless networks, have received increasing research interests. WNCSs have a wide spectrum of applications in mobile sensor networks, remote surgery, intelligent transportation, unmanned aerial vehicles, mobile robots, and so on. Security issues in WNCSs have been investigated from different viewpoints in recent years due to the increasing amount of cyber attacks that make WNCSs more and more vulnerable [2].

The joint optimization of controller and communication systems considering all the wireless network induced imperfections including packet error and delay, and all the parameters of both wireless communication and control systems has been recently studied in [1]. However, the optimization framework and therefore the solutions are limited to the objective of minimizing the total power consumption of the communication system, M-ary Quadrature Amplitude Modulation (MQAM) as the modulation scheme and Earliest Deadline First (EDF) as the scheduling algorithm.

WNCS consists of multiple controllers, each controlling a certain physical domain of the control system. One of the controllers is assigned as the coordinator. Coordinator controller is responsible for time synchronization in the

network, resource allocation for the network elements; i.e. running the resource allocation algorithms and informing the nodes about the decisions in a centralized framework, and monitoring the network topology and channel conditions.

The studies on the communication system design for Networked Control Systems (NCS) have remained very limited due to the lack of efficient abstractions of the control and communication systems in a joint manner. This led to either simplistic problem formulations by exclusion of some of the main control and communication system parameters or numerical solutions for specific scenarios avoiding the widespread use of the techniques.

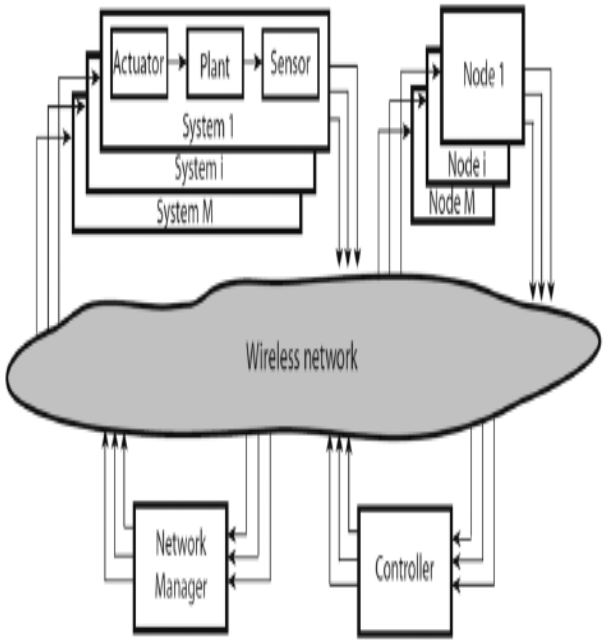

Fig. 1: Wireless network control system [5].

The rest of this paper is organized as follows in the first section we describe an introduction of about the Wireless networked control systems. In section II we discuss about the Wireless Networks. In section III we discuss about the rich literature for the Wireless networked control systems. In section IV we discuss about the problem statement as we getting from the rich literature survey, finally in section V we conclude the about our paper which is based on the literature survey and specify the future scope.

II WIRELESS NETWORKS

The network is composed of different types of cells varies with coverage areas, power, spectrum usage, supported services etc. For cellular technologies, like GSM, LTE, WiMax, Wireless in-local-loop, the cell dimension is moving from macro-cell to microcell to pico-cell and to femto-cell, to accommodate larger number of subscribers with enhanced performances with decreasing mobility. These technologies are normally providing services under licensed spectrum and in general controlled by service provider. Not only that, the relay station is also placed between the BS and subscribers so as to improve QoS performances. Apart from these licensed spectrum scenario, there are other wireless technologies, which are based on unlicensed spectrum, like WLAN, UWB, Bluetooth, RFID, etc. [9].

III RELATED WORK

In this section we discuss about the rich literature survey for the Wireless networked control systems and Wireless sensor-actuator networks in the field of wireless sensor networks**.**

[1] In this paper, they study the joint optimization of control and communication systems incorporating their efficient abstractions practically used in real world scenarios. The proposed framework allows including any non-decreasing function of the power consumption of the nodes as the objective, any modulation scheme and any scheduling algorithm. They first introduce an exact solution method based on the analysis of the optimality conditions and smart enumeration techniques. Then, they propose two polynomial-time heuristic algorithms based on intelligent search space reduction and smart searching techniques.

[2] This paper fills this gap from the aspect of control system performance. They consider the optimal jamming attack that maximizes the Linear Quadratic Gaussian (LQG) control cost function under energy constraint. After analyzing the properties of the cost function under an arbitrary

attack schedule, we derive the optimal jamming attack schedule and the corresponding cost function. System stability under this optimal attack schedule is also considered. We further investigate the optimal attack schedule in a WNCS with multiple subsystems. Different examples are provided to demonstrate the effectiveness of the proposed optimal denial-of-service attack schedule.

[3] In this paper, they extend the joint optimization problem for a generalized power cost function that represents many power-related objectives including minimization of total power consumption of the network and minimization of maximum power consumption among the nodes in the network and for any modulation scheme that satisfies certain properties including MQAM and MFSK. The optimization problem is formulated as a Mixed-Integer Programming problem thus difficult to solve for the global optimum.

[4] In this paper, they extend the joint optimization problem of power control, rate adaptation and scheduling with the objective of providing maximum adaptivity for general WNCSs employing continuous rate transmission model in which Shannon's channel capacity formulation is used for the achievable transmission rate. Upon proving the NP-hardness of the problem, they provide a framework for the design of a heuristic algorithm for scheduling and propose an optimal polynomial time algorithm for the power control and rate adaptation problem following the derivation of the optimality conditions.

[5] In this paper, they consider three recently proposed aperiodic control algorithms which have the potential to address this problem. By showing how these controllers can be implemented over the IEEE 802.15.4 standard, practical wireless control system architecture with guaranteed closed-loop performance is detailed. Event-based predictive and hybrid sensor and actuator communication schemes are compared with respect to their capabilities and implementation complexity.

[6] In this paper, the novel cross-layer optimized control (CLOC) protocol is proposed for minimizing the worst-case performance loss of multiple industrial control systems. CLOC is designed for a general wireless sensor and actuator network where both sensor to controller and controller to actuator connections are over a multi-hop mesh network. The design approach relies on a constrained max-min optimization problem, where the objective is to maximize the minimum resource redundancy of the network and the constraints are the stability of the closed-loop control systems and the schedulability of the communication resources.

[7] They propose a joint energy replenishment and scheduling mechanism so as to maximize the network lifetime while making strict sensing guarantees in the WRSN. They first formulate the problem in a general 2-D space and prove its NP-completeness. They then devise an f-approximate scheduling mechanism by transforming the classical minimum set cover problem and develop an optimal energy replenish strategy based on the energy consumption of nodes returned by the scheduling mechanism.

[8] This paper studies the network utility maximization (NUM) problem in static-routing rechargeable sensor networks (RSNs) with the link and battery capacity constraints. The NUM problem is very challenging as these two constraints are typically coupling in RSNs, which cannot be directly tackled. Existing works either do not fully consider the two coupled constraints together, or heuristically remove the temporally coupled part, both of which are not practical, and will also degrade the network performance.

[9] In this paper, they provide a survey of different tradeoff mechanisms proposed in the literature. The EE tradeoffs have been classified based on each protocol layer and discussed its affect in the network energy efficiency. These other QoS parameters include spectral efficiency, deployment, delay, routing, scheduling, bandwidth and coding etc. This survey also discusses the various EE techniques to improve energy-efficiency in infrastructure mode. Finally, the work provides an discussion, where impact of EE tradeoffs have been presented based on different wireless architecture towards realizing a green wireless communication network.

[11] In this paper, they propose a cross-layer optimized geographic node-disjoint multipath routing algorithm, that is, two phase geographic greedy forwarding plus. To optimize the system as a whole, our algorithm is designed on the basis of multiple layers' interactions, taking into account the following. First is the physical layer, where sensor nodes are developed to scavenge the energy from environment, that is, node rechargeable operation. Each node can adjust its transmission power depending on its current energy level.

[12] This paper presented a comprehensive survey on different energy management schemes in WSNs. These schemes are classified into two categories, energy provision based and energy consumption based. Energy provision approaches studies the energy source characteristics and develop algorithms depending on the energy availability to the sensor. They categorized such schemes as battery driven, energy harvesting, and energy transference based schemes. On the contrary, energy consumption based schemes refers to the algorithms and protocols that does not take into account the node's energy source.

IV PROBLEM STATEMENT

The communication system design for a WNCS requires guaranteeing the performance and stability of control system, with the limited battery resources of sensor nodes, despite the unreliability of wireless transmissions and delay resulting from packet transmission and shared wireless medium. The key parameters that need to be considered by both control and communication systems are the packet error probability, delay requirement and sampling period of the sensor nodes in the network. Decreasing the values of these parameters improves the performance of the control system. However, the energy consumed in the wireless transmission of the sensor nodes is a monotonically decreasing function of these parameters, when they are formulated as a function of the transmission power and rate of the sensor nodes in the network.

V CONCLUSIONS AND FUTURE WORK

Recently, sensors are developed in wireless sensor networks (WSNs) to scavenge energy from the natural environment, such as solar, heat, or vibration. Energy management in WSNs is defined as the set of rules to manage various energy supply mechanisms and then efficient consumption of the provided energy in a sensor node. The overall aim should be to manage energy in such a way that no node becomes energy deficient and the network is operational perpetually. It is important for a sensor node to have an efficient energy management scheme for the limited source as well as the application requirement should be managed in accordance to the available energy source. This paper presented a comprehensive survey on different energy management schemes in wireless sensor network's. In this article we present the survey for the energy consumption in the wireless sensor network and plan to implement in future best solution for the lowest energy consumption.

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