doi:10.1093/comjnl/bxr121

Capsule Reviews

FAIROUZ KAMAREDDINE

The Capsule Reviews are intended to provide a short succinct review of each paper in the issue in order to bring it to a wider readership. The Capsule Reviews were compiled by Fairouz Kamareddine. Professor Kamareddine is an Associate Editor of *The Computer Journal* and is based in the Department of Mathematical and Computer Sciences at Heriot-Watt University, Edinburgh, UK.

Tracking Animal Location and Activity with an Automated Radio Telemetry System in a Tropical Rainforest. ROLAND KAYS, SAMEER TILAK, MARGARET CROFOOT, TONY FOUNTAIN, DANIEL OBANDO, ALEJANDRO ORTEGA, FRANZ KUEMMETH, JAMIE MANDEL, GEORGE SWENSON, THOMAS LAMBERT, BEN HIRSCH AND MARTIN WIKELSKI

This paper describes an automated radio-telemetry system (ARTS) which is a sensor network designed to automatically, continuously and simultaneously track the locations and activities of radio-tagged wild animals living in a tropical rain forest. After a brief introduction to the motivation, the necessary backgrounds and the objectives, the system design goals are described. The ARTS system was designed to operate in the challenging conditions of Barro Colorado Island (BCI), Panama, over multiple years with as little human intervention as possible and the goals included robustness, scalability, spatial extensibility etc. The hardware, software and design choices of ARTS are explained in detail. Then, the results of 6-year system deployment of ARTS designed to track animal movements and activity patterns are reported and ARTS is evaluated across its goals. Furthermore, ARTS is compared with traditional localization/tracking technologies. Finally, a discussion of the real-world deployment challenges is given and the scientific impacts on ARTS are discussed.

Cross-Network Opportunistic Collection of Urgent Data in Wireless Sensor Networks. GIUSEPPE CARDONE, ANTONIO CORRADI AND LUCA FOSCHINI

The authors state that the possibility of integrating wireless sensor networks (WSNs) and Mobile Ad hoc NETworks (MANETs) paves the way to brand new cross-network routing opportunities to overcome the typical limitations of WSN data collection solutions. Stimulated by recent trends in mobile phone technology, they propose to exploit new mobile devices to help in WSN data collection. In particular, they propose an opportunistic solution that exploits the network layering created by a MANET within a WSN, without assuming any previous knowledge about node mobility, to differentiate and speed up data collection, especially tailored for most valuable urgent data. Interactions between MANETs and WSNs are only activated when necessary and dynamic protocols are used to find the best balance between a higher level routing layer and the cost of coordinating both MANETs and WSNs. First, the motivating scenario for urgent data delivery and the design guidelines for mobile WSN data collection are detailed. Then, the distributed architecture of the authors' proposal and its main facilities are described and the authors explain how they guarantee cross-network integration with a low communication cost by focusing both on the WSN layer and on the MANET layer. The WHOO (WSN Hybrid rOuting prOtocol) prototype that implements the proposed distributed architecture and protocols is then introduced and the power management strategy for adaptive MANET switch-off for energy saving is given. Extensions of WHOO to the CTP data collection protocol are discussed and experimental results are carried out to illustrate the feasibility of the approach.

EMS-MAC: Energy Efficient Contention-Based Medium Access Control Protocol for Mobile Sensor Networks. MAHDI ZAREEI, ALIREZA TAGHIZADEH, RAHMAT BUDIARTO AND TAT CHEE WAN

Mobility poses unique challenges to protocols in all layers, especially for the protocols in the medium access control (MAC) sublayer that are mainly responsible for packet scheduling, transmission, collision avoidance (CA) and resolution. Earlier MAC protocol designs have focused on energy efficiency. However, in addition to energy conservation and computation of resource dimensions, the requirement of handling mobility adds another dimension to sensor network protocols and involves a careful trade-off of energy efficiency, throughput and robustness. This paper is concerned with the study of the effects of node mobility on the performance of wireless sensor networks (WSNs), especially on their MAC sublayer, and proposes an energy-efficient solution for handling the mobility problem in the MAC sublayer. After an introduction to the energy-efficient MAC protocol called sensor MAC (S-MAC),

its enhanced version and its mobility-aware S-MAC (MS-MAC), the authors present their own scheme which is based on the MS-MAC protocol and uses the 'make before break' idea in handling mobile node handover from one virtual cluster (VC) to another in order to solve the high energy consumption problem of the MS-MAC protocol. A performance evaluation is carried out to compare EMS-MAC with S-MAC and its variants including the MS-MAC.

Repeatable Experiments with Mobile Nodes in a Relocatable WSN Testbed. OLOF RENSFELT, FREDERIK HERMANS, PER GUNNINGBERG, LARS-AKE, LARZON AND ERIK BJORNEMO

Various testbeds are used to experimentally and systematically evaluate wireless sensor networks (WSNs). Testbeds provide observation tools, methods and other ways to compare and evaluate alternative real hardware and software. Because real experiments cannot take place in a completely controlled and repeatable world as in simulations, it is a challenge to design a testbed, particularly with moving nodes. In this scenario, it is important to precisely measure mobility. For smartphone scenarios, a proposal is to replace humans with robots that can repeat the same movement from one experiment run to another with better precision. In an earlier publication, the authors developed Sensei-UU, a testbed that supports a robot-based solution for mobility at walking speeds and indoor usage. In this paper, the authors evaluate the movement precision of Sensei-UU in terms of variations in the received signal strength indicator (RSSI) from one run to another. After a discussion of related work on testbeds with mobile nodes, the authors discuss the variance in testbed experiments and the mobility variations in evaluating scenarios. Thereafter, the testbed design of Sensei-UU is given. Then, the impact of different sources of variance on experiments with mobile nodes in Sensei-UU is evaluated for three sources of invariance: imperfections in robot movement, imperfections and variation in hardware and software components, and external radio interference.

Lifetime Maximization in Wireless Sensor Networks Using a Mobile Sink with Nonzero Traveling Time. M. EMRE KESKIN, I. KUBAN ALTINEL, NECATI ARAS AND CEM ERSOY

The most prominent limitation of wireless sensor networks (WSNs) is the low energy capacities of the (usually large number of) sensors. Hence, lifetime maximization (the time until the first sensor dies) in WSNs is the objective of this paper. Since the sensors connected directly to a sink deplete their energies faster than the remaining sensors in the network, balancing the relaying load of the sensors using mobile sinks and controlling their mobility has been proposed in the literature. This paper extends the relevant literature by introducing two new mathematical programming models with four contributions. In particular, the two mathematical models employ a constant sink velocity, which leads to positive sink travel times, and fast and accurate heuristic techniques are proposed for the solution of these models. After reviewing existing studies on mobility of the sink in WSNs, the two models are proposed where data is sent through the shortest paths from sensors to the sink. In the first one, the length of the data routes is not limited and gathered data in a sensor is sent to the sink via the shortest path independent of the sink location. In the second model, the number of hops is limited and the data gathered in a sensor is again sent through the shortest path, but only if the sink is located close to the sensor such that the shortest path from the sensor to the sink obeys the hop limit condition. Thereafter, details of a heuristic approach for the solution of the models are proposed through a tour-construction heuristic and a tour-improvement heuristic. Computational results are then generated.

Real-Time On-Demand Motion Video Change On-Demand in Real Time in the Sensor Web Environment. ZEQIANG CHEN, LIPING DI, GENONG YU AND NENGCHENG CHEN

Many algorithms and systems for video change detection have been studied. However, such systems need to cope with the evolving and diversified demands of video change detection, need to support real-time execution and to have a sufficiently flexible architecture. The authors state that Open Geospatial Consortium (OGC) Web-based geoprocessing and Sensor Web technologies may provide a new way of thinking and a method to deal with such systems. This paper aims to design and implement a Sensor Web real-time or near real-time system for demand-based motion video change detection whose core components are a sensor observation service (SOS) and a web processing service (WPS). After an introduction to the necessary background, including the Open Geospatial Consortium SensorWeb Enablement OGC SWE standards, SOS (which obtains and manages sensor dynamical data) and WPS (which detects video changes on the Web), the system architecture of video change detection is given. This is provided by two sub-level architectures: the architecture for real-time motion video change detection and the architecture for demand-based WPS. To verify the proposed approach, a prototype was constructed, and a real-time experiment as well as an on-demand experiment were carried out.

A Hybrid Pull-Based with Piggybacked Push Protocol for Cache Sharing. KAI-TING YANG AND GE-MING CHIU

While many infrastructure-based wireless networks have been deployed to support wireless communication for mobile users, they suffer from drawbacks. A mobile ad hoc network (MANET) eases the problems by allowing mobile nodes to form a dynamic and temporary wireless communication network without pre-existing infrastructure. In contrast to an infrastructure-based network, a MANET is characterized by a continuously changing topology. This paper aims at one of the ultimate goals of MANETs, providing efficient data access to mobile clients. Sharing cache contents between mobile nodes

offers significant benefits. Furthermore, there are two types of cache-sharing techniques: push-based and pull-based where the push-based approach is appropriate for networks with nodes having limited cache size, while the pull-based one is preferred when cache size of a node is relatively large. There are however issues of concern (including the limited cache space that is available in a mobile node). This paper further investigates cache-sharing issues and proposes a hybrid protocol called Pull with Piggybacked Push (PPP) which facilitates cache sharing in a MANET environment and provides better scalability. After a review of the literature and related work, the authors describe the system model used in the paper and present the proposed PPP protocol which piggybacks caching information and advertises data items that have been cached locally without resorting to sending explicit advertisement messages. The main constituents of PPP (data access, index push and index vector update and cache replacement) are presented in detail and the authors report on a simulator built to evaluate the performance of the PPP protocol and to compare it with other protocols. The simulation results focus on the effect of: cache size, node mobility, data size, query rate and skewed data access. Finally, the paper discusses data structures for caching information and the possible interplay of the cache-sharing protocol and the routing protocol.

A Unitable Computing Architecture for Chip Multiprocessors. JIH-CHING CHIU, YU-LIANG CHOU, PO-KAI CHEN AND DING-SIANG SU

Heterogeneous chip multiprocessors (CMPs) comprise cores of varying size and computational capabilities which are connected together using an interconnection fabric. However, the die composition is set at design time, and hence the processor as a whole will not be able to adapt to diverse applications. To solve such adaptability limitation, the authors propose an alternative CMP architecture called hyperscalar so that the amount and computational capabilities of the CMPs can be adjusted on the fly. After an overview of the hyperscalar architecture and of the mechanisms for uniting the core resources, three new system-level instructions (UNI, SetPC and ADJ instructions) are defined to allow programmers to dynamically unite and adjust the core resources. The instruction analyzer (IA) can spot and handle these instructions as they pass through. The paper explains how IA deals with the register data flow, the instruction flow and the memory data flow and presents its basic microarchitecture which involves fetching, analyzing and dispatching. The authors move to present the design and architecture of the proposed virtual shared register file (VSRF) concept that helps the instructions of a thread in different cores to logically face a uniform set of register files. Experimental evaluations of the sequential performance of the hyperscalar architecture are carried out.

Facilitating Efficient Object Tracking in Large-Scale Traceability Networks. YANBO WU, QUAN Z. SHENG AND DAMITH C. RANASINGHE

The authors propose a generic approach for efficient tracing and tracking of objects in large-scale, distributed environments. First, the authors introduce the needed preliminaries of traceable networks and a new framework for modeling moving objects in discrete spaces (MOODS). This new model can represent moving objects and their attributes in an economic way. Then, a P2P approach that can process traceability queries in an effective and efficient way is given. This approach is built on top of the distributed hash table (DHT)-based overlay network where an object and its latest state are indexed at a deterministic node called gateway node while keeping the information of the object path (IOP) at the nodes where the object has been observed. The IOP contains information about the source and destination nodes, and hence it can be used to quickly answer queries to obtain the trace of an object. Since the data volume might be very high in a large traceable network, the authors classify the objects arriving at a node within a small period of time into different groups according to the prefix of their ids. Here, the objects are indexed in groups to the gateway node which is chosen according to the prefixes by the DHT network. The indexing process consists of three phases: grouping, routing and index-persisting. The authors give the timing of grouping, the grouping algorithm, the algorithms for indexing, index lookup and index-persistence, and analyze the indexing process and the managing of uncertainty. Next, algorithms are given (and analyzed) to process two kinds of tracing queries: item level and range queries. Experiments are carried out to evaluate the performance of the indexing algorithms, the performance of query processing and the effect of the prefix length on the group-indexing algorithm/load balancing/indexing performance of traceable networks. Finally, an example application is given and followed by a discussion of related work.