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MESSAGE FROM COMMSOFT TC CHAIR

The Technical Committee on Communications Software (TC-COMMSOFT) examines methods and techniques devoted to advancement of the formal methods and tools, use of system analysis and design, methodology for development of communications protocols as well as application of general Software Engineering approaches for the purpose of development of communications applications. The issues addressed by the TC-COMMSOFT include domain-specific languages and practices of using them. Developing of "middleware" between networks and applications and the usefulness and usability of it is also a topic.

Using Backward Traffic Difference Estimation for Efficient Energy Saving Schedules in Wireless Devices

Constandinos X. Mavromoustakis
Department of Computer Science,
University of Nicosia
46 Makedonitissas Avenue, P.O.Box 24005
1700 Nicosia, Cyprus
mavromoustakis.c@unic.ac.cy

1. Introduction

Many application scenarios where wireless sensor nodes support full mobility whereas they are powered by limited capacity batteries and limited memory equipment, pose significant resource exchange restrictions to the associated resource sharing process. The network topology dynamically changes due to the power management interface activities of the sensor nodes to conserve energy. Nodes aggressively switch their transceivers off causing sudden network partitioning. This causes several connectivity issues to the nodes as they are no longer capable for hosting the resource sharing process in a reliable manner. It is a major challenge to face intermittent connectivity issues and at the same time provide minimization of the energy consumption onto each node according to the resource exchange activity. In order to explore a compromise between the growing needs in communication network resources and the limitations that pose according to the users' demands, it is necessary to apply algorithms and control mechanisms for the regulation of the data traversal [1] and flows. The message volume among users and control messages among terminals grows exponentially [2], whereas the associated traffic dynamics in the channels becomes complicated and chaotic [3]. There is a great need to explore these traffic dynamics through models that primarily investigate the behavior of the traffic through time and create a model for hosting this behavior, enabling optimal traffic control.

When wireless devices share resources following the opportunistic manner, the resource exchange process faces several connectivity challenges that need to be faced via reactive combinatorial practices. This letter investigates a proposed and implemented scheme for sharing resources using the opportunistic networking paradigm whereas, it enables Energy Conservation (EC) for the nodes by allocating dissimilar Sleep/Wake schedules to wireless devices. The scheme considers the resource sharing process which according to the duration of the traversed traffic through the associated channel, it impacts the Sleep-time duration of the node. The letter shows that the traffic's backward difference can be defined as a significant parameter to assign the next Sleep-time duration for each node according to the activity duration and the volume of the traffic for each node. The scheme is evaluated through Real-Time implementation by using dynamically moving MICA2dot wireless nodes [4] which are exchanging resources in a Mobile Peer-to-Peer manner. Results have indicated the scheme's efficiency for enabling EC and provide the ground which the smart traffic schemes will be expanded in order to offer adaptive EC in Real-Time.

2. The Backward Difference Traffic Estimation for Energy Conservation

As traffic is of our main focus, there is a need to associate the traffic-enabled parameters in time with the energy metrics for each node. The input nodal traffic is being considered in this letter, and estimated according to the Backward Traffic Difference (BTD). Wireless nodes, regardless if they are acting in the network as intermediate forwarding nodal points or as destinations, they have to be self-aware in terms of power and processing as well as in terms of accurate participation in the transmission activity. There are many techniques such as the dynamic caching-oriented methods explored in the recent past. The present letter utilizes a hybridized version of the proposed adaptive dynamic caching [5] where, if a destination node will be set in Sleep state then the packets destined for this node will be cached into an intermediate node. This mechanism is considered to behave satisfactorily and enables simplicity in real time implementation [6], while it prolongs the network lifetime according to the volume difference of the incoming traffic.

As the BTD scheme is entirely based on the aggregated self-similarity nature of the incoming traffic for a certain node, there should be an evaluation scheme in order to enable the node to Sleep, less or more according to the previous activity moments. This means that, as more as the cached traffic is, there will be an increase in the sleep-time duration of the next moment for the destination node. Let $C(t)$ be the capacity of the traffic that is destined for the Node i in the time slot (duration) t, and $C_{N_i(t)}$ is the traffic capacity that is cached onto *Node (i-1)* for time t. Then, the 1-level Backward Difference of the Traffic is evaluated by estimating the difference of the traffic while the *Node(i)* is set in the Sleep-state for a period, as follows:

$$\begin{aligned}
\nabla C_{N_i(1)} &= T_2(\tau) - T_1(\tau-1)\\
\nabla C_{N_i(2)} &= T_3(\tau-1) - T_2(\tau-2)\\
&\vdots\\
\nabla C_{N_i(n+1)} &= T_n(\tau-(n-1)) - T_2(\tau-(n-2))
\end{aligned} \tag{1}$$

where $\nabla C_{N_i(1)}$ denotes the first moment traffic/capacity difference that is destined for *Node(i)* and it is cached onto Node (i-1) for time τ, $T_2(\tau)-T_1(\tau-1)$ is the estimated traffic difference while packets are being cached onto *(i-1)* hop for recoverability [5]. Equation (1) depicts the BTD estimation for one-level comparisons, which means that the moments are only being estimated for one-level ($T_2(\tau)-T_1(\tau-1)$). The Traffic Difference is estimated so that the next Sleep-time duration can be directly affected according to the following:

$$\delta(C(T)) = C_{total} - C_1, \forall C_{total} > C_1, T \in \{\tau-1, \tau\} \tag{2}$$

where the Traffic that is destined for *Node(i)*, urges the Node to remain active for $\frac{\delta(C(T))}{C_{total}} \cdot T_{prev} > 0$.

When a node admits traffic, the traffic flow t_f, can be modeled as a stochastic process [9] and denoted in a cumulative arrival form as $A_{t_f} = \{A_{t_f}(T)\}_{T\in N}$, where $A_{t_f}(T)$ represents the cumulative amount of traffic arrivals in the time space [0..T]. Then, the $A_{t_f}(s,T) = A_{t_f}(T) - A_{t_f}(s)$, denotes the amount of traffic arriving in time interval (*s, t*]. Hence the next Sleep-time duration for *Node (i)* can be evaluated as:

$$L_i(n+1) = \frac{\delta(C(T) \mid A_{t_f}(s,T))}{C_{total}} \cdot T_{prev}, \forall \delta(C(T)) > 0 \tag{3}$$

For the case that the $\delta(C(T)) < 0$ it stands that: $\delta(C(T)) = C_{total} - C_1, \forall C_{total} < C_1, T \in \{\tau-1, \tau\}$, and $\frac{\delta(C(T))}{C_{total}} \cdot T_{prev} < 0, \forall T_{prev} > T_{prev}(\tau-1)$, the $C_{N_i} < 0$ and the total active time increases gradually according to the following estimation:

$$T_{sleep} = T(\tau - t_1) - (-C_{N_i}) = T(\tau - t_1) + T_{C_{N_i}} \tag{4}$$

where the $T_{C_{N_i}}$ is the estimated duration for the capacity difference for $C_{N_i} < 0$, whereas the Sleep-time duration decreases accordingly with Equations (3) and (4), iff the $C_{N_i} < 0$. Taking into consideration the above stochastic estimations, the Energy Efficiency EE_{t_f} can be defined as a measure of the capacity of the *Node(i)* over the *Total Power consumed* by the *Node*, as:

$$EE_{t_f}(T) = \frac{C_{t_f}(T)}{TotalPower} \tag{5}$$

Equation 5 above can be defined as the primary metric for the lifespan extensibility of the wireless node in the system.

3. Real-time performance testing and evaluation using the MICA2 sensors equipped with the MTS310 sensor boards

Real-time experiments and measurement studies were conducted for the precise evaluation and the offered energy conservation from the BTD scheme. During the evaluation, 35 nodes were used, with each link (frequency channel) having max speed reaching data transmission at 38.4Kbits/s, and the wireless network is organized in 8 overlapping clusters. Each source node transmits one 512-bytes (~4Kbits-light traffic) packet asynchronously and randomly each node selects a destination. Network structure has been implemented as a [N-1] row, [N-1] column for each node being a possible destination as developed in [6]. Each device has an asymmetrical storage capacity compared with the storages of the peer devices. The range of the capacities for which devices are supported are in the interval 1MB to 20MB[1] to encourage the caching mechanism to take place where needed. Indicative and comparative results are shown in figures 1, 2(a) and (b).

[1] The capacity for each device can be tuned according to the volume of the Traffic in the configuration process.

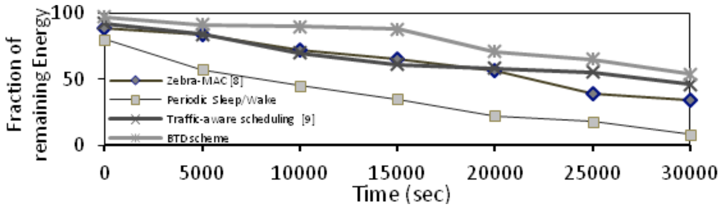

Figure 1. The fraction of the remaining Energy through time using real-time evaluation for different schemes.

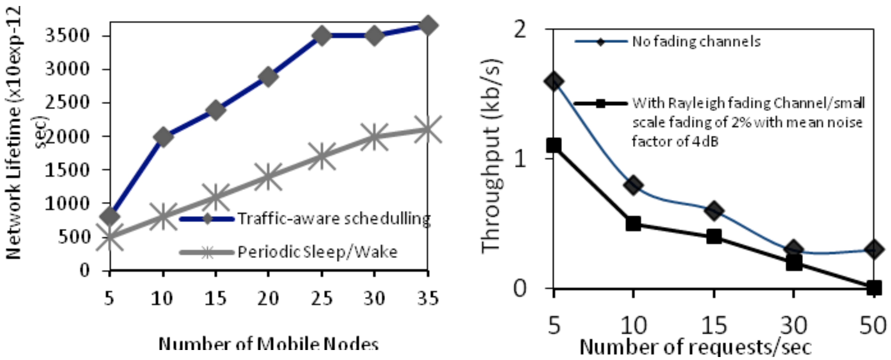

Figure 2(a) and 2(b). Network Lifetime with the Number of Mobile Nodes; and the Throughput response of the system hosting the proposed scheme with the Number of requests for certain fading measures' characteristics.

4. Conclusion

In this letter, a measurement study is presented, using the BTD scheme hosted on wireless nodes during their resource exchange process. According to real-time results extracted, the designed model prolongs the network lifetime by reducing the energy consumed and the active-state duration that the node experiences, while maintaining the requested scheduled transfers.

5. Future trends and prospects in BTD for EC

Since wireless communication accounts for a large proportion of energy consumption and multimedia data are often of large size, there is a great need to balance the multimedia and delay-sensitive content sharing with performance and energy consumption. Further streams in research encompass the Mutli-fractal estimations where different moments of the traffic variations will be considered and modeled using self-Similar, *N-Window Fractality* measurements. This estimation will be designed to support efficiently multimedia traffic (delay sensitive) while it potentially offers EC. In addition currents trends in EC research include the Energy profiling and tagging for WSNs where by using a social model the associated traffic can be tagged and classified according to QoE parameters of the tagged users.

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Constandinos X. Mavromoustakis is currently an Associate Professor at the Department of Computer Science at the University of Nicosia, Cyprus. He received a five-year dipl.Eng in Electronic and Computer Engineering from Technical University of Crete, Greece, MSc in Telecommunications from University College of London, UK, and his PhD from the department of Informatics at Aristotle University of Thessaloniki, Greece. He has worked as a Research Associate at the Computer Architecture and Communications Lab at the PDSG (Parallel and Distributed Systems Group) at the Department of Informatics, Aristotle University of Thessaloniki, Greece. He has participated in many EU funded projects whereas, his research interests are in the area of spatial and temporal scheduling, self-organizing scheduling and adaptive behavior in wireless and multimedia systems.

Data Routing for Urban Sensing in Mobile Sensor Networks

Takahiro Hara, Keisuke Goto, Yuya Sasaki, Shojiro Nishio
Department of Multimedia Engineering,
Osaka University, Japan
Email: {hara,goto.keisuke,yuya.sasaki,nishio}@ist.osaka-u.ac.jp

1. Introduction

Due to the recent advances in wireless communication and sensing technologies, there has been increasing interest in Mobile Sensor Networks (MSNs) that are constructed by mobile nodes with sensor devices. *Urban sensing*, in which ordinary people cooperate for data gathering with some incentive, is a typical example of MSNs[1][4]. Traditionally, urban sensing assumes some infrastructures, i.e., the Internet, for communication and data gathering. However, since many applications share and compete for limited network resources in the Internet, it is desirable to minimize traffic that MSNs inject into the Internet. As a result, MANET (Mobile Ad Hoc Network) based approaches without any infrastructures have recently attracted much attention for urban sensing in MSNs. In such MSNs (which we simply call MSNs), sensor nodes sense an environment (e.g., noise, temperature, and people density), and a sink gathers the sensor readings using multi-hop radio communication between sensor nodes (and the sink).

In MSNs (composed of ordinary people), the number of sensor nodes is generally very large, and thus, there are basically many sensor nodes for each geographical point that can sense (cover) the point in the entire sensing area (i.e., dense MSNs). From the perspective of applications, a lot of same sensor readings are not useful, but just waste limited network bandwidth and battery of sensor nodes. Rather, in most cases, applications require a certain geographical granularity of sensing, e.g., sensor readings of every 100 [m] × 100 [m] square. Therefore, to reduce the data traffic for data gathering, it is desirable to efficiently gather sensor readings so that the geographical granularity required from an application can be guaranteed with the minimum number of sensor nodes. Achieving this is not easy because sensor nodes moves freely, and thus, sensor nodes that can sense a specific point dynamically change. A naive method is that a sink determines sensor nodes that perform sensing and collects the readings from those nodes at every cycle of sensing. However, this method produces large traffic for message exchanges.

In this article, we present our recent work addressing this issue. In [2], we

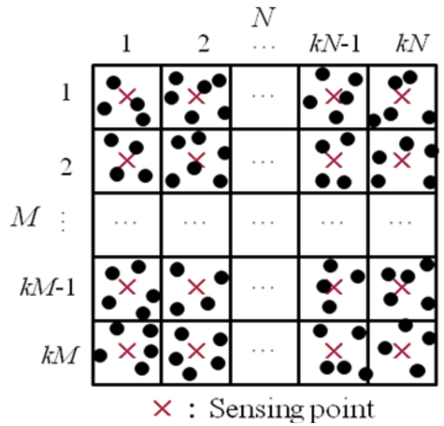

Figure 1: Sensing area and sensing points

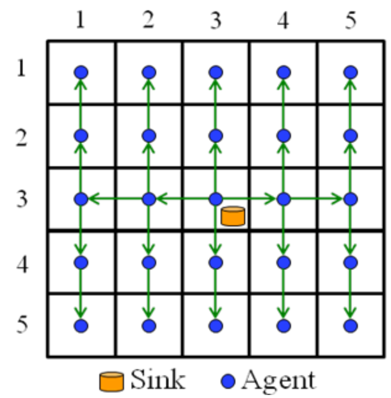

Figure 2: Forwarding tree

have proposed a data routing method that efficiently gathers sensor readings using mobile agents in dense MSNs. A mobile agent is autonomously operates on a sensor node and moves between sensor nodes. In our method, mobile agents are generated by the sink and allocated on sensor nodes located near the sensing points, which are determined from the requirement on geographical granularity. Each mobile agent moves from the currently located sensor node to the sensor node nearest from the sensing point responding to the movement of sensor nodes, which makes the mobile agent continuously locates near the sensing point. Every time when the sensing time comes, sensor nodes where agents locate perform sensing and send the readings to the sink. Our method can reduce the traffic for gathering sensor data since mobile agents control sensor nodes for sensing operations and transmissions of sensor readings. In this article, we also discuss some directions of our future work.

2. Assumptions and Outline of Our Method

2.1. *Assumptions*

The sensing area is assumed to be a two-dimensional plane whose horizontal to vertical ratio is M:N (M and N are positive integers). The application specifies its requirement of the geographical granularity of sensing as an integer of $k^2 \cdot M \cdot N$ (k=1,2,...). Then, the sink divides the sensing area into $k \cdot M \times k \cdot N$ lattice-shaped sub-areas and determines the center point of each sub-area as a sensing point, which is the target of data gathering (see Figure 1).

The communication range of each sensor node is a circle with a radius of r. Each sensor node is equipped with a positioning device such as GPS, and they communicate with each other using multi-hop radio communication based on their positions (i.e., geo-routing[3]). Each sensor node freely moves in the sensing area, while the sink is stationary. Since the number of mobile nodes is very large, there are many sensor nodes for each geographical point that can sense (cover) the point in the entire sensing area.

2.2. *Outline of our method*

In our method, initially, the sink generates mobile agents and deploys them in the network. Specifically, the sink sends the agent data to $k^2 \cdot M \cdot N$ sensing points. The sensor node closest to each sensing point receives the agent data and boots a mobile agent. At each sensing time, the mobile agents send sensor readings generated by sensor nodes on which they run to the sink. Moreover, if a sensor node on which a mobile agent runs moves away from the sensing point, the mobile agent moves from the sensor node to another node which is the closest from the sensing point. In the following, we describe each of the procedures.

Deployment of mobile agents:

Our method deploys mobile agents in the network with small traffic. Specifically, the sink sends the agent data along the *forwarding tree* (described below) that is created based on the geographical relationships among sensing points. The procedures of the sink and mobile agents to deploy mobile agents are as follows. First, the sink generates the agent data and sends it to the sensing point in the sub-area in which the sink locates using the geo-routing protocol. Then, the sensor node located closest to the sensing point in its existing sub-area receives the agent data, and then boots a mobile agent. As the initial operation, the mobile agent retransmits the agent data to the sensing points in some of sub-areas which are adjacent to its existing sub area (in a predetermined manner). This procedure is repeated until mobile agents in all sub-areas are activated. Through the above procedures, mobile agents dynamically construct a tree structure for forwarding the agent data (e.g., Fig. 2), which we call the forwarding tree.

Transmission of sensor data:

Mobile agents deployed at (near) sensing points send the sensor data held by sensor nodes on which these agents operate to the sink at every sensing time. Our method can reduce the traffic of sending sensor data since mobile agents compress the received sensor data that are sent along the forwarding tree in the reverse direction. More specifically, at every sensing time, mobile agents located in sub-areas of the top and bottom edges of the sensing area start to send their sensor readings (sensor data) to the mobile agents that forwarded the agent data to them. Then, each mobile agent that receives the sensor data from all children in the forwarding tree aggregate the received sensor data and its sensor reading and forwards the aggregated data to the parent in the forwarding tree. This procedure is repeated until the mobile agent located in the sub-area where the sink locates receives the sensor data. Finally, that mobile agent sends the data to the sink. By aggregating sensor data at each intermediate node, its size can be reduced.

Movement of mobile agent:

If a sensor node on which a mobile agent operates moves away from the sensing point, it may not be able to sense (cover) the point. To avoid such situations, mobile agents move from the current sensor nodes to other nodes which are closest to the sensing points. Specifically, a mobile agent starts moving when the distance between the sensing point and itself becomes longer than threshold α. Here, α is a system parameter which is set as a constant smaller than the half of the communication range of sensor nodes ($r/2$) and the sensing coverage, which can guarantee that a sensor node on which a mobile agent operates can communicate with all sensor nodes located near from the sensing point and can sense the data at the sensing point.

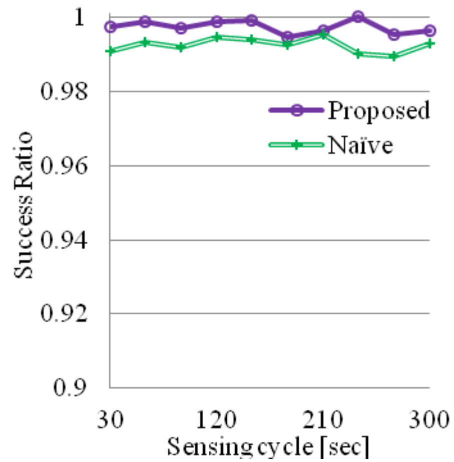

Figure 3: Simulation result (sucess ratio)

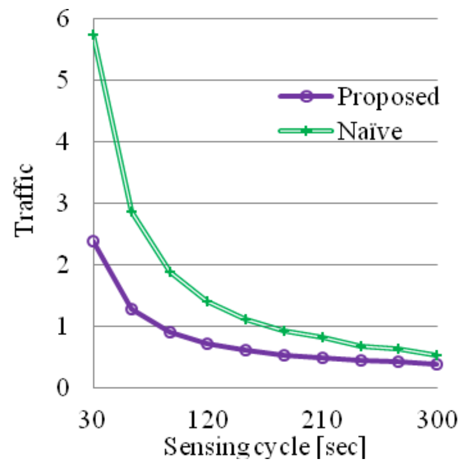

Figure 4: Simulation result (traffic)

2.3. *Performance study*

We conducted simulation experiments to verify the effectiveness of our method. In the simulations, a sink and 2,000 sensor nodes exist in an area of 1,000 [m] × 1,000 [m]. The sensing coverage (radius) and communication range of each node are respectively 50 [m] and 100 [m]. The sink collects sensor data from 25 lattice-shaped sub-areas (200 [m] × 200 [m]) at every 30 [s]. For comparison, we measured the performance of a naive method that sends request messages (queries) to the center positions of all sub-areas and gathers sensor data from nodes locating near those positions at every sensing time. Figures 3 and 4 show the simulation results. From the results, we can confirm that our method drastically reduces the traffic while achieving high success ratio for sensor data collection. This shows the effectiveness of our approach where mobile agents autonomously control data routing and aggregate the sensor data.

3. Future Directions

In [2], for the purpose of simplicity, we assume node failures (e.g., users having mobile node turn off the wireless communication device) do not occur. However, in real environments, node failures do occur. Therefore, we plan to extend our proposed method so that mobile agents monitor the living of other agents with each other and reboot a missing mobile agent.

We also plan to further reduce the traffic for data collection by aggregating sensor data more effectively. For example, since sensor observations at near locations tend to be similar with each other, we can further aggregate them by utilizing some sensor data compression techniques proposed in conventional studies. It is also effective to dynamically determine an appropriate tree structure according to system situations instead of a static one as shown in Figure 2.

In addition, we plan to extend our proposed method to handle sensing errors since sensor observations generally contain some errors and sometimes the errors become very large (outlier). A possible approach is that neighboring mobile agents exchange their sensor readings to check the accuracy before sending the readings to the sink.

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Biography

Takahiro Hara received the B.E, M.E, and Dr.E. degrees in Information Systems Engineering from Osaka University, Osaka, Japan, in 1995, 1997, and 2000, respectively. Currently, he is an Associate Professor of the Department of Multimedia Engineering, Osaka University. He served and is serving as a Program Chair of several international conferences such as IEEE MDM'06 and 10, IEEE AINA'09, and IEEE RDS'12. His research interests include distributed databases, peer-to-peer systems, mobile networks, and mobile computing systems. He is a senior member of IEEE, ACM, and IEICE and a member of two other learned societies.

Keisuke Goto received the B.E. degree from Kyoto Institute of Technology and the M.I.S. degree from Osaka University, Japan, in 2010 and 2012, respectively. He is currently a research student at the Department of Multimedia Engineering of Osaka University. His research interests include Mobile Wireless Sensor Networks.

Yuya Sasaki received the B.E. and M.I.S degrees from Osaka University, Japan, in 2009 and 2011, respectively. He is currently pursuing his Ph.D. at the Graduate school of Information Science and Technology of Osaka University. His research interests include Mobile Ad Hoc Networks and Vehicular Ad Hoc Networks.

Shojiro Nishio received his B.E., M.E., and Ph.D. degrees from Kyoto University in Japan, in 1975, 1977, and 1980, respectively. He has been a full professor at Osaka University since August 1992. He served as a Vice President and Trustee of Osaka University from August 2007 to August 2011. His research interests include database systems and multimedia systems for advanced networks such as broadband networks and mobile computing environment. He has served and is currently serving as an editor of several international journals including IEEE Trans. on Knowledge and Data Engineering, VLDB Journal, ACM Trans. on Internet Technology, and Data & Knowledge Engineering. He is also a fellow of IEEE, IEICE, and IPSJ, and is a member of five learned societies, including ACM.

Impacts of Duty-Cycle on Overlapping Multi-hop Clustering in Wireless Sensor Networks

Jiaqi Xu[1], Lei Wang[1], Can Ma[1], Lei Shu[2]
[1]School of Software, Dalian University of Technology, China
[2]Department of Multimedia Engineering, Osaka University, Japan
{ssdutjiaqi, macan0711}@gmail.com, lei.wang@ieee.org, lei.shu@live.ie

This paper focuses on studying the impacts of a duty-cycle based CKN sleep scheduling algorithm for a multi-hop overlapping clustering algorithm in wireless sensor networks (WSNs). It reveals the fact that waking up more sensor nodes cannot always increase the average cluster size but can always increase the cluster overlapping degree in a given duty-cycle based WSN.

Multi-hop Overlapping Clustering Algorithm (MOCA) [3] is one of the earliest researches that specifically aims at controlling the overlapping degree among clusters, which are generated to cover the entire 1wireless sensor network (WSN). A key drawback of this research work is that all sensor nodes are assumed to be always awake during the clustering process. However, in most realistic situations, sensor nodes should be scheduled to dynamically sleep to conserve energy.

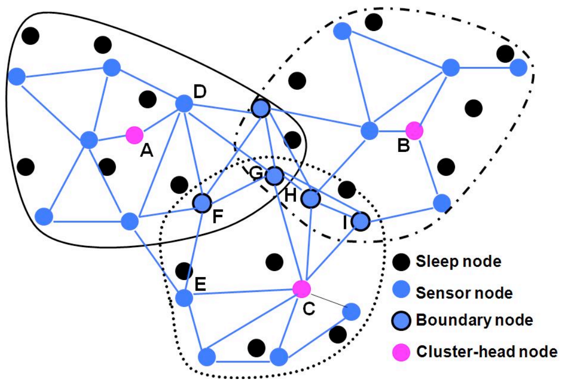

Figure 1 : An example of overlapped clusters in a duty-cycled WSN.

In [1], Nath *et al.* proposed a Connected *k*-Neighborhood sleep scheduling algorithm, named as CKN, for duty-cycle based WSNs. CKN algorithm aims at allowing a portion of sensor nodes in the WSN to go to sleep but still keeping all the awoken sensor nodes connected. The number of sleeping nodes in the WSN when applying CKN algorithm can be adjusted when changing the value of *k*.

In this paper, we are extremely interested in seeing the executing performance of MOCA in duty-cycled WSNs as shown in Fig.1. Particularly, our interests fall into the following two aspects:

Will waking up more sensor nodes increase the average cluster size for any given WSN?

Will waking up more sensor nodes increase the cluster overlapping degree for any given WSN?

To check the impacts of duty-cycle on the MOCA algorithm, we implemented it into our NetTopo WSNs simulator [2], in which the CKN algorithm was implemented.

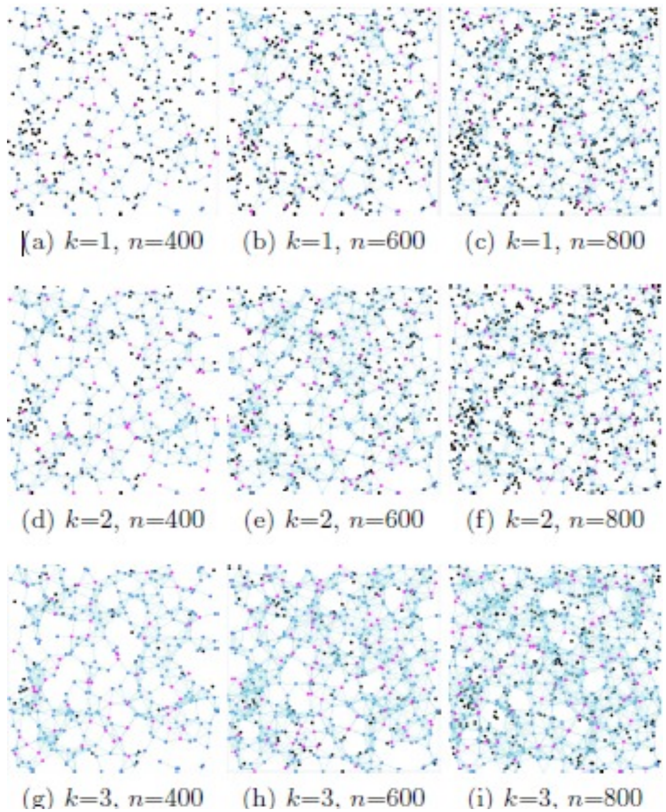

Figure 2 : Impact of network connectivity for executing MOCA in a CKN based WSN in different network size *n* with changed *k* values.

In our work, the number of deployed sensor nodes representing different network sizes *n* are increased from 100 to 1000 (each time increased by 100). The value of *k* in CKN algorithm is changed from 1 to 10 (each time increased by 1). The nodes were randomly placed according to a uniform distribution on a 700 * 700m^2 area. For every number of deployed sensor nodes, we use 100 different seeds to generate 100 different network deployments. The transmission radius for each node is 60*m*. The consumed energy to transmit a *l*-bit message over distance *d* is: $E_{\_TX}(L,d)=E_{\_elec}\cdot L+\epsilon_{\_amp}\cdot L\cdot d^2$, and we assume that the radio dissipates $E_{\_elec} = 50\ nJ/bit$ to the transmitter or receiver circuity, $\epsilon_{\_amp} = 100pJ/bit/m^2$, and the data rate is *20kbps*. Through repeated experiments, we assure that each point in the plotted results represents an average of ten simulation runs each with 100 different seeds.

As shown in Fig. 2, nine snapshots of executing the MOCA algorithm in CKN based WSNs are provided. The sleeping rate decreases when k gets bigger which is the result of applying the CKN algorithm. The number of cluster heads produced by the MOCA algorithm will increase with the growth of *k* (from 1 to 3) when the network size *n* remains the same.

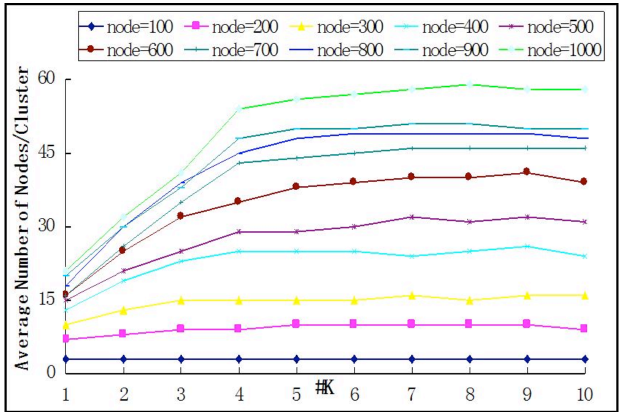

Figure 3 : Average cluster size vs. the value of *k*.

Fig. 3 shows the simulation results of the average cluster size (average number of nodes in a cluster) when the value of *k* changes for different number of deployed sensor nodes. The observation that we can gain from this simulation result is that: for a certain WSN.

with a particular network density, **waking up more sensor nodes cannot always increase the average cluster size. Instead of that, the average cluster size will reach a relative stable value**, and we will work further on it in our future work.

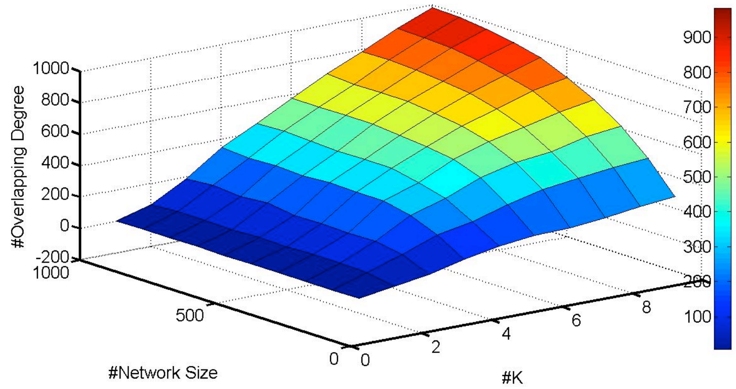

Figure 4 : Overlapping degree vs. the value of *k*.

Fig. 4 shows the three-dimensional relationship of network size *n*, *k* in CKN algorithm, and the cluster overlapping degree (the total number of boundary nodes) in the MOCA algorithm. It clearly reflects that: for a certain WSN with a particular network density, **waking up more sensor nodes can always increase the cluster overlapping degree.**

This research result is meaningful since it provides a new method to further control the average cluster size and cluster overlapping degree in MOCA algorithm.

Acknowledgment

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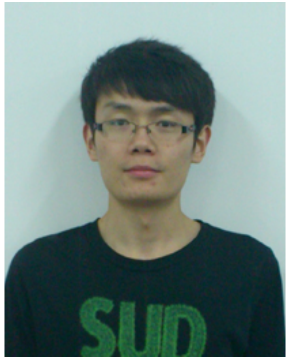
Biography

Jiaqi Xu is currently a graduate student in Dalian University of Technology, China. She received the B.S. from Dalian University of Technology, China, in 2011. After that, she continued further education without examination. Her research interests include wireless mesh networks and wireless sensor networks. Her published research mainly focuses on performance analysis of wireless mesh networks. She is a student member of ACM and CCF (China Computer Federation).

Lei Wang is currently an associate professor in Dalian University of Technology, China. He received the B.S., M.S. and Ph.D. from Tianjin University, China, in 1995, 1998, and 2001, respectively. He was a Member of Technical Staff worked with Lucent Bell Labs Research China (2001-2004), a senior engineer at Samsung, South Korea (2004-2006), a research scientist in Seoul National University (2006-2007), and a research associate with Washington State University, Vancouver, WA, USA (2007-2008). His research interests include wireless ad hoc network, sensor networks and network security. He is a member of IEEE, ACM and CCF (China Computer Federation).



Can Ma is currently a graduate student in Dalian University of Technology, China. He received the B.S. from Dalian University of Technology, China, in 2011. After that, she continued further education without examination. His research interests mainly focus on wireless sensor networks. His published papers pay much attention to performance optimization of geographic routing in wireless sensor networks. He is a student member of ACM and CCF (China Computer Federation).

Lei Shu (M'07) is a currently Specially Assigned Researcher in Department of Multimedia Engineering, Graduate School of Information Science and Technology, Osaka University, Japan. He received the B.Sc. degree in Computer Science from South Central University for Nationalities, China, 2002, and the M.Sc. degree in Computer Engineering from Kyung Hee University, Korea, 2005, and the PhD degree in Digital Enterprise Research Institute, NUIG, in 2010. He has published over 90 papers in related conferences, journals, and books. He had been awarded the Globecom 2010 Best Paper Award. He has served as editors of Wiley, European Transactions on Telecommunications, IET Communications, Wiley Wireless Communication and Mobile Computing, KSII Transactions on Internet and Information Systems (TIIS), International Journal of Sensor Networks, Journal of Communications, etc. He has served as various Co-Chair for international conferences, e.g., ICC, ISCC, and IWCMC; TPC members of more conferences, e.g., MASS, ICCCN, ICC, Globecom, and WCNC. His research interests include wireless sensor network, security, and multimedia communications. He is a member of IEEE and IEEE ComSoc.

Wireless Sensor Network Deployment

Nadjib AIT SAADI
University of Paris-Est Creteil Val de Marne - IUT Vitry
nadjib.aitsaadi@u-pec.fr

Abstract:
In this paper, we address the problem of static wireless sensor network deployment. Our research aims to generate the best network topology in relation to the following objectives: i) the cost of deployment (number of sensors), ii) the quality of monitoring, iii) network connectivity, and iv) the network lifespan. To overcome the great complexity involved, we proposed several heuristic deployment strategies: Differentiated Deployment Algorithm (DDA), Bernoulli Deployment Algorithm (BDA), Potential Field Deployment Algorithm (PFDA) and Multi-Objective Deployment Algorithm (MODA). The obtained results outperform the related deployment strategies.

Key words: WSN, Deployment, Optimisation, Metaheuristic

1. Introduction

A wireless sensor network is a set of nodes deployed over an area and intended to monitor, supervise, and detect an event (e.g. temperature, humidity, light, etc) [1]. When an event is detected, the network must be able to forward the detection measurement to the base station (sink) in order to inform the user and to execute the associated procedures. For example, if the temperature in a monitored forest exceeds a predefined threshold (e.g. 70 degrees Celsius), the sink will send an alarm to the fire department so that the fire's propagation can be easily controlled.

As the deployment field is usually large and the communication range is limited, most sensors cannot reach the sink in one hop. To ensure network connectivity, i.e. to guarantee sensors can send data to the sink, multi-hop communication is required. Figure 1 shows a basic wireless sensor network architecture. A sensor node incorporates five modules [2]: i) controller, ii) memory, iii) sensors, iv) communication device, and v) power supply. We will now describe each component in detail.

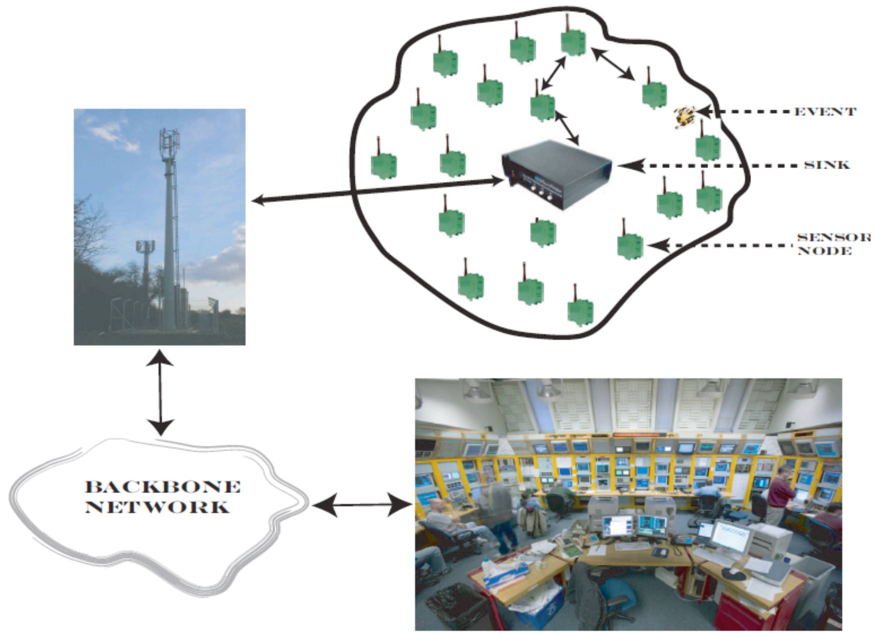


Figure 1: Wireless sensor network architecture

Quality of monitoring is an important factor of any wireless sensor network. To achieve adequate quality, each point in the deployment field should be covered by at least one sensor. Consequently, when an event occurs in the deployment area, the network will be able to detect it. However, even if an event occurs within a sensor's coverage circle, detection cannot be fully guaranteed, due to interference, noise, and obstacles. Sensor event detection is probabilistic and as the detection probability increases (close to 1), the quality of monitoring improves. Each point in the deployment area could request an event detection probability that a wireless sensor network should satisfy. The distribution of the requested event detection probability will not be uniform as it will depend on the application, deployment field, and the event characteristics. The requested event-detection probability distribution can also be influenced by geographical factors. For example, in a forest, high detection probabilities (close to 1) are requested for risky areas (e.g. those close to chemical deposits inhabited areas), and low detection probabilities for low-risk areas.

A user communicates with a wireless sensor network via the base station. The sensor nodes should be able to send the detected data to the sink. A path between each sensor and the sink must be established otherwise, the user will not be notified and the event will propagate in the deployment field with no reaction from the user. For example, if a fire occurs in a forest and a sensor detects it but cannot send information to the sink (user), the fire will spread and will be more difficult to extinguish. The network topology should be connected for as long as possible so as to inform the user about any evolution of the monitored event.

Sensors are equipped with batteries which contain a limited quantity of energy. Generally, once the sensors are deployed it will be difficult and/or expensive to reach the deployment field and as a result the batteries are not often recharged. Consequently, in wireless sensor network energy is a rare and precious resource. It is important to optimize the network lifetime and much work has been done to minimize energy consumption at the different protocol stack layers. Then, any intervention in the deployment field can be delayed for as long as possible.

2. Problem handled

In this paper, we will focus on the problems surrounding static wireless sensor network deployment. The network contains only one base station and its position is known. Our research aims to establish the best network topology while also taking into account

1. Cost of deployment: Minimizing the number of sensors deployed.
2. Quality of monitoring: Ensuring each point in the deployment area offers an event detection probability greater than or equal to a predefined threshold. The threshold values mainly depend on the event characteristics, deployment field properties, and application.
3. Network connectivity: Calibrating the separating distance between sensor nodes. The distance must be less than or equal to a sensor's communication range.
4. Network lifetime: Minimizing energy consumption without modifying the protocol stack. Generating the best topology to maximize load balancing and minimize overhearing, collisions, and bit error rate.

3. Proposals

To resolve the wireless sensor network deployment problem described above, we proposed a selection of wireless sensor network deployment strategies. However, due to the complexity of the factors involved, we will set about solving the whole problem in three stages.

In the first stage, the problem tackled will not include all the objectives - only the deployment cost and the quality of monitoring will be considered. Then, each new stage will build upon the previous stage by incorporating another objective. Below, we will specify the sub-problem studied in each stage and the corresponding proposal.

In the first stage, the problem is simplified and we only focused on the deployment cost and the quality of monitoring. Our aim here is to minimize the number of sensors and to satisfy the requested event detection probabilities for each point in the deployment field. To ensure network connectivity, we can assume that a sensor's communication range is so large. We then propose a heuristic called the **Differentiated Detection Algorithm** (DDA) [3]. It is based on image processing and mesh representation which is used in 3D modeling. The main idea of DDA is to represent the deployment field with meshes as an image. The mesh nodes represent the sensor positions and the mesh arcs represent the separating distance between sensor nodes. The obtained results outperform all related proposals except Diff-Deploy strategy [4], which was put forward after our proposal.

In the second stage, we will build on the first stage by introducing a network connectivity objective. The connectivity range can be fixed to any value and the deployment algorithm will guarantee the connectivity of the network topology. To resolve the problem, we will propose two deployment strategies based on the Tabu Search metaheuristic. The first strategy is called the **Bernoulli Deployment Algorithm** (BDA) [5]. The decision to deploy a sensor at any point in the deployment field is carried out using a random variable, which follows a Bernoulli distribution. The obtained results are better than those obtained from previously suggested deployment strategies already found in the literature. However, because of the random nature of the deployment decision, the method will not be able to ensure full satisfaction of the requested event-detection probabilities. For this reason, we went on to propose another heuristic strategy, named the **Potential Field Deployment Algorithm** (PFDA) [6], based on the Tabu Search metaheuristic and the artificial potential field (virtual force). This method is based on robotic and seeks to find the best trajectory for a robot from an initial point to a target point in the presence of obstacles. The simulations show an improvement when compared with the related deployment strategies.

In the final stage, we set about resolving problem as a whole by introducing the network lifetime objective. To reduce the energy consumption we will not improve the protocol stack. Our aim is to find the best deployment topology that maximizes the load balancing among the sensor nodes, minimizes the number of packets forwarded by the nodes, and minimizes over-hearing and interference. Moreover, the proposal minimizes the number of sensors and guarantees network connectivity and the requested quality of monitoring. To reduce energy consumption, the method adapts the topology to the routing, MAC, and physical layers implemented in the sensors. We will propose a new deployment algorithm named the **Multi-Objective Deployment Algorithm** (MODA) [7]. It is based on the Multi-Objective Tabu Search metaheuristic and, as in our previous work, the artificial potential field. We assume ZibBee-based nodes where the routing protocol is Ad hoc On Demand Distance Vector (AODV) and the MAC/Physical layers are specified in IEEE 802.15.4 standard. The MODA's results outperform all the related proposals and the lifetime is greatly improved.

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Biography

Nadjib AIT SAADI is associate professor of computer science at University of Paris-Est Creteil Val de Marne - IUT Vitry since September 2011. He is a member of Laboratory of Image, Signal and Intelligent Systems (LISSI). From June 2010 to August 2011, He was research fellow at INRIA - HIPERCOM team. Nadjib AIT SAADI obtained the PhD in computer sciences with honors from LIP6 - Pierre & Marie Curie university (Paris 6) in France on March 11th 2010. In September 2006, he gained a MSC diploma in Computer Science - Networking from Pierre & Marie Curie university (Paris 6) in France. In September 2005, he received Engineer Diploma in computer science from the High National School of Computer Science in Algiers.

Structured Sharing of Human Digital Memories

Haseeb Ur Rahman, Madjid Merabti, David Llewellyn-Jones, Sud Sudirman
H.Ur-Rahmam@2008.ljmu.ac.uk, {M.Merabti, D.Llewellyn-Jones, S.Sudirman}@ljmu.ac.uk
School of Computing and Mathematical Sciences
Liverpool John Moores University
Liverpool, L3 3AF, UK

Abstract- Most people now commonly capture large portions of their lives digitally, including through photographs, video, audio and other data types. Human digital memory stores are intended to help users store, manage, search and share this data with others. In this paper we consider Peer-to-Peer networks as a means of storing and sharing digital memories. We introduce memory threads as a means to structure the underlying Peer-to-Peer network in a way that reflects the semantic data within the memories. This allows us to demonstrate improved efficiency over existing unstructured and community-structured networks. In addition, we discuss benefits including the potential to expose serendipitous moments as a consequence of the network structure.

1. Introduction

In recent years there has been a huge increase in interest in human life digital memories. Despite a very long history – stretching back to Vannevar Bush's astonishingly prescient vision of the memex back in 1945 [1] – it's only in recent years that the collection of digital memories has become an everyday pastime.

This has been driven by a variety of factors. Perhaps most importantly, technological advances have made the pursuit of capturing significant portions of our memories in digital form a viable proposition.

When Jim Gemmell and colleagues reinvented Bush's vision for a digital age in 2002 [2], commercial hard drive capacity was measured in tens to hundreds of gigabytes. In their paper, they predicted that "terabyte hard drives will be common and inexpensive" within five years. They also noted that, in an age of terabyte storage "only video is up to the task of readily filling a terabyte in a year." It's clear that their predictions have come to pass, with multi-terabyte drives now widely available.

However, this only satisfies one part of the requirements; the explosive growth of digital camera ownership – largely driven by camera-phone adoption – also constitutes an enabling factor. The smartphone is likely to result in new types of memory capture (making use of sensors other than audio and visual) but this has yet to reach its full potential.

Finally, and perhaps just as importantly, from a technological perspective, the realization of ubiquitous networking has offered the opportunity not just to capture, store and manage digital memories, but also to *share* them. This has provided more forceful *reasons* for capturing memories, driving the social change that has led to the pursuit becoming so widespread.

However, much of the current focus is on social networking via the Web. While astonishingly successful, the Website model introduces a number of important limitations. Most notably, the centralized model suffers from scalability issues, while at the same time removing control from the hands of individual users.

A large body of work exists looking at alternative networking models for managing human digital memories, and a number of important challenges remain in the area. Among these are challenges relating to how best to structure, manage and retrieve digital memories; questions about how to present memories to the user in an effective form; and how to implement practical Peer-to-Peer (P2P) technologies for sharing data securely in the network.

One relatively unexplored area is that of how managing the underlying structure of the network impacts on the higher-level user-oriented characteristics of the system, such as searching, correlating, presenting and exploring digital memories. We believe the two must be considered in tandem. The structure of a P2P network implementing a shared digital memory system is crucial for the efficiency of the system from a user perspective. Moreover, by reflecting certain relationships between memories in the relationships between peers, we also believe that the network can actually expose new information about the memories that might otherwise remain obscured. For example, serendipitous moments, which constitute fortuitous events characterised by shared memories discovered between pairs or groups of people, can be discovered through correlation of memories that can be facilitated by correlations existing as part of the underlying network itself. This relies on a semantic connection between the network structure and the data stored in the network.

These ideas, and our initial studies into how to manage, structure and implement P2P human digital memory stores will be expanded on further in the remainder of this paper. In Section II we consider related work and existing projects looking at human life memories and shared memory systems. Section III discusses the notion of memory threads, and our implementation of them within a P2P network. Results that demonstrate the characteristics of this network structure are presented in Section IV. Finally conclusions and our future research directions are presented in Section V.

2. Related Work

The development of digital human life memory systems has become an important area of research in the last decade, and a number of research projects have tackled a variety of issues within the area. An important appeal is that the work crosses multiple disciplinary boundaries, from social analysis to software design to hardware development.

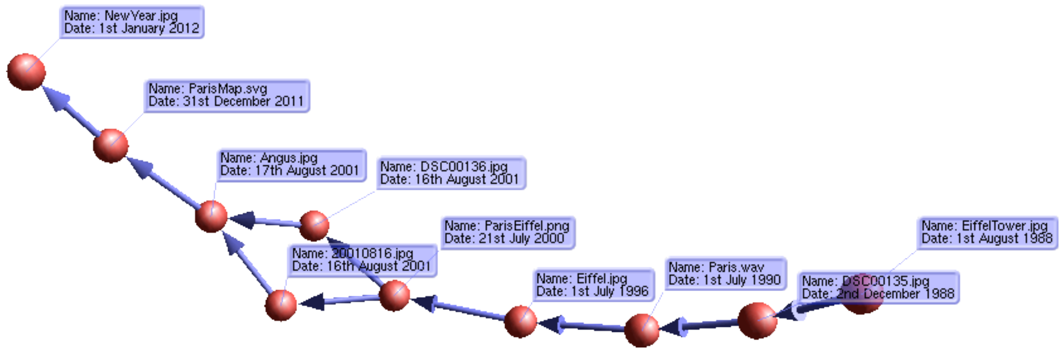

Figure 1. Peers connected to form a memory thread.

This breadth was encapsulated in the MyLifeBits project [2]. This included software for the storage, management, tagging and retrieval of data, hardware and software for the automatic capture of memories, and the social exercise of actually capturing the life memories of Gordon Bell, a member of the project team.

It's widely acknowledged that retrieving memories in an efficient way is of critical importance, and developing effective means for visualising large collections of memories is important for facilitating this. Doherty and Smeaton developed the Groundtruthing interface for presenting an event-based segmentation of SenseCam-collected images [3]. The concept of narrative is explored by Byrne and Jones through the use of card sorting; they found strategies used by people to assemble a multimodal story formed from captured memories were highly consistent [4]. Nishimura *et al.* [5] also develop their visualisation from chronological narratives, presented on a 3D geographical map. They also propose the interesting extension of considering multiple people's lifelog streams in a single visualisation. Clearly chronology and narrative represent important elements for all these visualisation methods.

Tied in to this are the notions of searching and tagging content. While visualisations can help to manage and discover memories manually, this is likely to become impractical for the potentially huge quantities of image, audio and video data that can be collected across the span of a human lifetime.

Searching directly based on image contents is a developing area, but text-based search remains the most practical approach to searching for content. Tagging of data with appropriate metadata offers a suitable transformation of data into a usable text-based form. Consequently work on automated tagging, such as that of Ono *et al.* [6], Wannous *et al.* [7] and Ismail *et al.* [8] aims to tackle the issue without increasing the burden on the user to manually annotate large quantities of captured data.

In our work we assume tagging as a pre-requisite for the management of data. Images, audio, video and other data can all support additional metadata relating to the subjects of the data, their location, time, and so on, and therefore build on this existing work in the area.

All of these aspects apply equally to an individual's isolated memory store and the memory stores that are shared between people. However, when considering network sharing a new challenge emerges: how and where should data be stored within the network in order to facilitate searching and sharing both within and across memory stores?

P2P networks have been widely proposed as a sensible means of decentralised storage and sharing of digital memory data [9, 10]. Compared to filesharing or other P2P networks, memory stores are likely to require a structure that relates more closely to the semantics of the data stored in them. For example, the memories of more interest to me are likely to be those of my friends and family in the first instance. The memories of others may also be of interest, but this will likely be only as they relate to particular topics.

This semantic structure must be distinguished from the traditional interpretation of what is referred to as a structured P2P network. Under the traditional meaning, although the structure does depend on the data, invariably this is limited to an abstract or highly narrow interpretation of its semantic content (*e.g.* the hash of the filename of a piece of data) [11].

A number of researchers have looked at structuring memory stores based on communities coalescing around particular topic areas. The Maze P2P network [12] creates communities based on social relationships, resulting in the automatic generation of interest groups. While this has been demonstrated as a practical approach, the technique nonetheless relies on central servers to form matches and coordinate structuring of the network. Upadrashta *et al.* [13] also focus on social relationships, layering a semantic search algorithm on top of an unstructured Gnutella P2P network. Finally Modarresi *et al.* [14] develop the idea of interest-based communities (IBCs) in a P2P network for improving search efficiency and data organisation. We build on these ideas, creating a more refined structure to allow more focussed searching. By incorporating more of the semantic information into the network, we believe otherwise hidden relationships can be revealed that might otherwise be missed.

3. Memory Threads and Serendipitous Moments

Unlike traditional P2P networks, digital memory stores present a number of unique restrictions and characteristics. When attempting to improve performance by choosing an appropriate structure for the network, these have to be considered carefully.

An important restriction is that users are likely to insist on storing their own digital memories. This contrasts with structured P2P networks such as Chord or Kademlia [11], which assume the data can be moved to an appropriate peer within the network in order to facilitate efficient routing.

In addition, when searching for memories, users invariably have a particular entity, event or characteristic in mind, which forms part of a wider narrative, as discussed earlier.

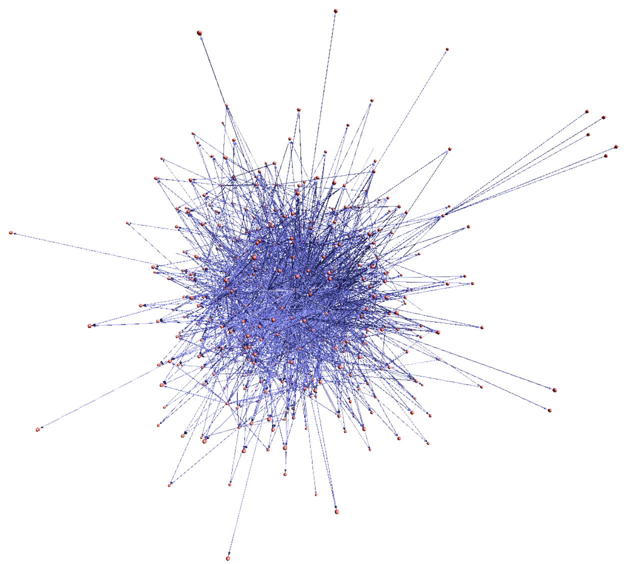

Figure 2. Unstructured P2P network.

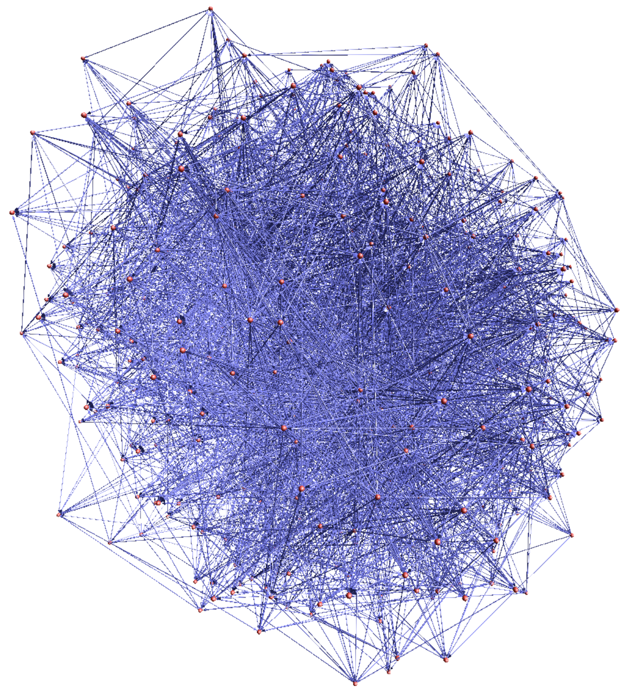

Figure 3. Interest-based community P2P network.

To try to capture this, we propose the notion of *memory threads*. Memory threads are created through the combination of a *selection criterion* and an *indexing criterion*. The selection criterion acts as a filter for selecting digital memories (photographs, audio files, video files, *etc.*) that relate to a particular topic. The topic or theme might be a particular person, an event, a place and so on. The indexing criterion on the other hand must take the form of a variable that satisfies the requirement of being a total ordering. A total order is a transitive, antisymmetric ordering such that for any items a and b, either $a \leq b$ or $b \leq a$. In other words, the order must be applicable to any pair of elements that match the selection criterion.

The most common indexing criteron is that of time, but any other criterion could be applied as long as it can also be represented as a total order. Other examples might include data size, distance from a given location, or hue (along with a suitably restrictive selection criterion).

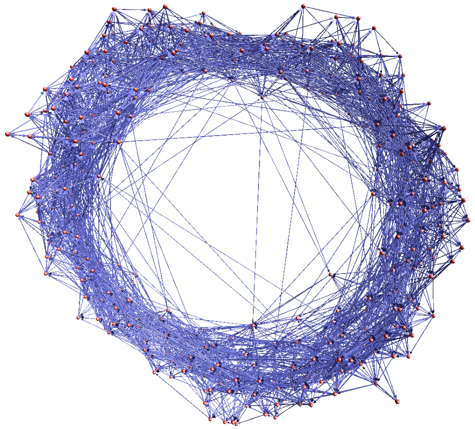

Figure 4. Memory thread-based P2P network.

The P2P network structure is shaped through the use of memory threads by connecting together pairs of nodes that match the selection criterion, and which are directly adjacent in the ordering induced by the indexing criterion.

As an example, we could consider memories related to the Eiffel Tower. In this case the selection criterion would be the tower itself (*e.g.* photographs that capture it) and the indexing criterion might be time. In this case, peers would become connected in a manner similar to that shown in Figure 1.

Note that a total ordering doesn't imply uniqueness, hence there may be multiple memories at the same position in the ordering. In this case, connections are made between all adjacent nodes, as can be seen where the graph splits in Figure 1.

While a network containing only a few memory threads would inevitably be ineffective and likely even disconnected, overlaying multiple threads within the network causes crossing between threads. Searching therefore involves following the semantically most appropriate thread until this crosses a more relevant thread. Eventually the appropriate thread will be found, which can then be traversed, moving in the correct direction depending on the search criteria.

A particularly attractive aspect of memory threads is that they also allow serendipitous moments to be discovered at the 'crossing points' of the memory threads; this extends the work of Ismail *et al.* [9]. For example, two people present at the Eiffel Tower on the same day will exist at the convergence of three threads (or within a given sphere of it): the threads relating to the two individuals and the Eiffel Tower thread itself. While we don't explore this further here, we note it as an interesting direction for future investigation.

In the next section we will present our results based on the implementation of memory threads within a simulated P2P network, demonstrating that for focussed themed searches within a P2P digital memory store, memory threads offer efficiency improvements over existing P2P network structures.

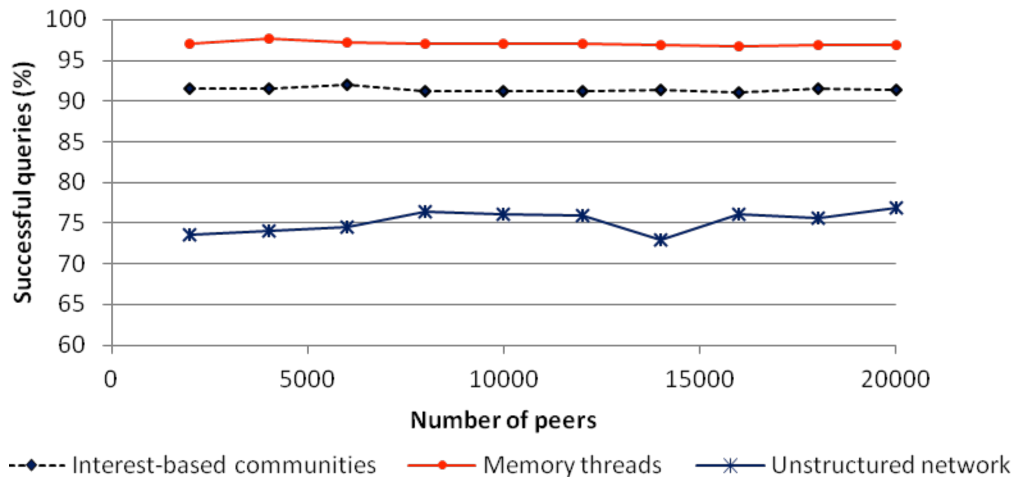

Figure 5. Successful queries for different P2Pnetwork types and sizes.

4. Results

In order to establish the efficiency characteristics of a memory thread-structured network we extended the community-based P2P simulator developed by Modarresi *et al.* [14]. The software simulates the process of searching for themed data within a P2P network. We extended the existing unstructured and IBC structured simulations to allow memory thread networks to be compared with these existing schemes.

To understand the results we ran simulations of networks with increasing size between 2000 and 20000 peers. For illustrative purposes, example networks containing 500 peers can be seen for each of the three networks in Figures 2-4.

For each experiment queries were broadcast in the network and the successful response rate measured. These results can be seen in Figure 5, where each data point represents an average of 15 runs.

As can be seen, both memory threads and IBC offer a considerable improvement over the unstructured network. Moreover, they also retain their performance even as the size of the network increases. However, it can also be seen that MTC performs consistently better than IBC across all network sizes.

The successful query rate represents only one metric by which performance can be measured. In future work we intend to develop a more comprehensive understanding of both the characteristics of the network and the reasons for this improved performance. However, as an initial set of results, we see this as positive evidence that more focussed network structures, such as those provided by memory threads, are worthy of deeper investigation within the context of P2P digital memory stores.

5. Conclusion

In this paper we considered the question of how digital memories can be shared and searched in an efficient manner using P2P network technology. We introduced the notion of memory threads, a networking approach that reflects semantic information from the data being stored in the network structure in an intrinsic way. While semantic networks are not new themselves, our approach constitutes a novel way to exploit the specific characteristics of human digital memories to provide a more efficient storage mechanism.

In particular, through simulation results we are able to show that the technique out performs existing community and unstructured P2P networks, suggesting that a focussed structuring mechanism has the potential to provide significant benefits.

In addition to the improved performance, we believe the use of structures such as memory threads can also expose information about the data contained in the network, such as the existence of serendipitous moments that might otherwise remain obscured.

However, there is clearly a great deal of potential to develop these ideas further. In the first instance we aim to use our implementation to explore other metrics and characteristics of memory threads, to establish more clearly the nature of the networks they generate. Moving on from this, we hope to consider a wider selection of network structures, for example by considering more complex ordering mechanisms such as lattices as indexing criteria.

Another question that arises relates to metrics that can be applied to the network. Networks generated using memory threads appear not to conform to traditional expectations, in that many metrics correlated with efficiency suggest they should not perform as well as they do. We hope to develop metrics that capture the specific benefits that semantically structured networks exhibit.

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Madjid Merabti is Professor of Networked Systems and Security, and Director of the School of Computing and Mathematical Sciences, Liverpool John Moores University, UK. He is a graduate of Lancaster University in the UK. He has over 20 years' experience in conducting research and teaching in the areas of Computer Networks (fixed and wireless), Mobile Computing, Computer Network Security, Digital Forensics, Multimedia, Games Technology, and their applications. Professor Merabti is widely published with over 160 publications in these areas and leads the Distributed Multimedia Systems and Security Research Group, which has a number of UK Government, EU, and industry-supported research projects. He has graduated 26 PhD students in the course of his work. He is principal investigator in a number of current projects in Digital Rights Management, Games Technology, Multimedia Networking, Mobile Networks Security and Privacy Architectures and Protocols, Secure Component Composition

in Ubiquitous Personal Networks, Networked Appliances, Mobile and Ad-Hoc Computing Environments, and Sensor Networks. He is also Director of a newly created Research Centre for the Protection of Critical Infrastructure (PROTECT www.protect-ci.org), addressing the challenges of innovating, building and managing new critical infrastructure systems for the 21st century that are both resilient to unpredicted changes and secure against external attacks.He holds a number of Journal Editorships and is currently involved with the following journals:Associate Editor for Elsevier Computer Communications Journal

- Associate Editor for Wiley Journal of Security and Communication Networks
- Area Editor for IEEE Communications Magazine series on Networked Appliances and Home Networking.
- Associated Editor for Springer Peer-to-Peer Networking and Applications Journal.
- Associate Editor for Advances in Multimedia Journal and the Journal of Computer Systems, Networks, and Communication (Hindawi Publishing).

Professor Merabti serves on the steering committee for the IEEE Consumer Communications and Networking (CCNC) series of conferences, and the International Symposium on Ubiquitous Intelligence and Smart World and is actively involved in international conferences as TPC chair and TPC member. He has delivered a number keynote talks at International Conferences on: Digital Life Memories, Wireless Networks, Network Security, and Critical Infrastructure Security among others.

Report of Leading SIG activities

SIG on Multimedia Computing and Service Activities
Head: Prof. Liang Zhou

- Activities during year 2011-2012
  - Establish the information platform
  - Advertise message in our group
  - Serve for the group members all over the world
- Wireless Communications and Mobile Computing (http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291530-8677)
  - Editor: Liang Zhou
- IET Communications (http://scitation.aip.org/IET-COM)
  - Editor: Liang Zhou
- International Journal of Ad Hoc and Ubiquitous Computing Special Issue on Internet of Things
  - Guest Editors: Liang Zhou etc.
- Telecommunication Systems Special Issue on Wireless Communications
  - Guest Editors: Liang Zhou etc.
- ICST GreeNets 2011
  - Chairs: Liang Zhou etc.

SIG on E-Health Activities
Head: Prof. Joel Rodrigues

- International Journal on E-Health and Medical communications
  - Continue as Editor and Chief
- IEEE HealthCom 2013 in Lisbon, Portugal
  - Chairs: Joel Rodrigues, etc.

SIG on Communications software for Networked Robots Activities
Head: Yacine Amirat

- Special Issue on Ubiquitous Networked Robots (UNR) of Journal Annals of Telecommunications (JAT)- Springer
- Meeting with the TC networked robots of IEEE RAS Society during IROS'11 conference in San Francisco (September 2011).
- Contribution to the specification document "Networked robotic systems" with a focus on high level knowledge representation and reasoning issues, bridges with ubiquitous and pervasive computing and ambient intelligence. This action was conducted in coordination with the SIG "SC for Ubiquitous computing" coordinated by Abdelghani Chibani

SIG on Communications Software for Ubiquitous Computing Activities
Head: Abdelghani Chibani

- Organization of the international conference IST-AWSN'12 which will be held in conjunction with the 3rd International Conference on Ambient Systems, Networks and Technologies (ANT-2012) in Niagara Falls, Ontario, Canada, August 27-29, 2012
- Due to the overlap of topics between the this SIG and the networked Robots SIG, Dr. Chibani and Prof. Amirat propose to the committee to make a single SIG where networked robots become a sub topic. **TC CS Agree.**
- They propose to add an additional topic to the list of the topics that are addressed in this new SIG. This new topic concerns the use of ontologies to create autonomic & ubiquitous networks and communicating objects, which become of a main interest. This actively is involved in a standardization action at the IEEE standard body, in order to define new ontology standards that can be applied for robotics, automation and their communication issues. **TC CS Agree.**

SIG on Communications software for Vehicular AdHoc Networks Activities
Head: Rami Langar

- Organized a workshop UBIROADS 2011 (Third International Workshop on ITS for Ubiquitous Roads) co-located with GIIS 2011, Da Nang, Vietnam, in August
- Dr. Langar ask to be replaced by another person. **The TC CS agree.**
- **The chair will ask volunteers and nomination will be in next TC CS meeting in ICC 2012.**

TC OFFICERS AND NEWSLETTER EDITORS

TC Officers

Names	**Affiliation**	**Email**
Abdelhamid Mellouk	University of Paris-Est, Créteil	mellouk@univ-paris12.fr
Joel Rodrigues	Institute of Telecommunications, University of Beira Interior	joeljr@ieee.org
Lynda Mokdad	University of Paris-Est, Créteil	lynda.mokdad@u-pec.fr

Editor-In-Chief

Names	**Affiliation**	**Email**
Lynda Mokdad Lei Shu	University of Paris-Est, Créteil Osaka University, Japan	lynda.mokdad@u-pec.fr lei.shu@live.ie