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Mobility based Real Time Communication in Wireless Sensor Networks

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ABSTRACT
Wireless Sensor Networks face unavoidable challenges in the areas of connectivity, network lifetime and energy efficiency in its implementation. At the same time, urgent data captured by the sensor nodes need to be processed at real time with low message latency and maximum utilization of the bandwidth. This paper presents an in-depth analysis of the different data transfer methods available under mobile platform and a performance analysis of different real time bandwidth allocation schemes in a Wireless Sensor Network. An optimal solution for the communication in mobile platform is analyzed and found out to be the Rendezvous based solution implemented with Relayed Data Collection Algorithm to achieve an acceptable value of network lifetime and energy consumption. In case of real time communication, the optimal time slot bandwidth allocation scheme – O-TDMA has been proved to have met all the performance parameters and found out to be the optimal solution in real time communication in a Wireless Sensor Network. We propose to couple these two optimal solutions (the Rendezvous based solution implemented with Relayed Data Collection Algorithm to gain optimum mobility and the O-TDMA to gain optimum real time communication) to create an efficient and effective real time communication in a mobile platform

General Terms
Wireless Sensor Networks, Real Time Performance Analysis, Mobility-Based Communication.

Keywords
Wireless Sensor Network, Rendezvous, O-TDMA, Worst Case Achievable Utilization, Transmission Constraints

1. INTRODUCTION
A wireless sensor network (WSN) consists of a large number of communicating nodes that each has a limited supply of energy. Sensor nodes (*source nodes*) are often deployed once, at fixed locations, but sensor locations may also change. Client nodes (*sink nodes*) use sensor data, as mobile nodes inside the network or as nodes at the network edge. Among many challenges faced while implementing and designing wireless sensor networks, *maintaining connectivity* and *maximization of network lifetime* stands out as the most critical considerations. The mobile devices offer to be the solution for the connectivity and lifetime issues in Wireless Sensor Networks. In many deployment scenarios, mobile platforms are already available in the deployment area, such as soldiers in battlefield surveillance applications, animals in habitat monitoring applications, and buses in a traffic monitoring application. In other scenarios mobile devices can be incorporated into the design of the Wireless Sensor Network architecture, such as airborne and ground-based vehicles. With communication devices on mobile platforms, the connectivity and energy efficiency (hence, network lifetime) problems can be addressed as follows:

- Connectivity: Mobile devices can be used to carry information between the distributed sensor nodes in the network.
- Network lifetime: The energy consumption in the sensor nodes is reduced considerably by transmitting information through the mobile devices which reduces multi hop communication between nodes.

On the other hand, the real-time performance is influenced mainly and directly by the implementation of bandwidth allocation among the nodes in Wireless Sensor Networks. To ensure the transmission of messages before their deadline with relatively high traffic load, bandwidth must be properly allocated to individual nodes, which has been proved to be a very challenging work. Existing wireless MAC protocols and allocation schemes, with their own limitations, focus more on optimizing system throughput and do not adequately consider the real-time guarantees requirements of sensor networks. Therefore, the search for both the proper optimized allocation schemes and their performance evaluations has become one of the mainly aspects in research on real-time network performance recently.

2. MOBILITY IN WIRELESS SENSOR NETWORKS
In recent years a number of approaches have been proposed exploiting the mobility for data collection in Wireless Sensor Networks. These approaches have been categorized according to the properties of sink mobility as well as the wireless communication methods for data transfer:

2.1 Mobile Base Station (MBS)-Based Solutions

In Wireless Sensor Networks, stationary sinks forms the central locations where the communication to different nodes are concentrated. As a result of this concentration, the sensor nodes at the vicinity of the sink lose energy, leading to disconnection of the sink from the network. The primary aim of MBS-based solutions is to move the sink in the network so that the energy consumption is distributed evenly to all the sensor nodes.

2.1.1 Base Station Relocation

In this proposed scheme [2], the main objective is to move the MBS along the periphery of the sensing field, such that the energy consumption is equally distributed among the sensor nodes and the overall energy consumption is minimized. To implement this scheme, time is divided into rounds when the MBSs are stationary. At the end of every round, the position of the MBS is recomputed using inductive logic programming (ILP) methods minimizing an objective function. The two objective functions explained in [2] states the total energy consumption of all the sensor nodes in the network and maximum energy consumption of any sensor node in the next round. According to the simulation results, the first objective function results in more data collected in the entire network lifetime, whereas, the second objective function proves a longer network lifetime, which is defined as the time until the first node dies.

2.1.2 Joint Mobility and Routing

This proposal [3] is motivated by the uneven energy consumption by the sensor nodes in the Wireless Sensor Networks with stationary sinks. The load balancing of the sensor nodes [3] becomes necessary to distribute the energy consumption among the nodes in the network. It is shown that the network lifetime is improved considerably by replacing stationary sinks with mobile sinks and it is further shown in [3] that the optimum movement of the sinks is to follow the trajectory where the deployment area is circular. Finally, a heuristic solution for joint mobility and routing is presented where it is states that, the MBS with move along a circular trajectory and the sensor nodes communicate with the MBS by the shortest paths to reduce the energy consumption in central parts of the network. Nodes outside the MBS trajectory use paths composed of circular arcs followed by straight lines directed toward the trajectory centre to reach the MBS. The residual energy of the outer nodes is utilized otherwise not used for this strategy.

2.1.3 Move and Sojourn

Investigation for prolonged network lifetime is also discussed in [4]. The study proposed a framework by considering the placement of sensor nodes and MBSs in grids. Delays associated with MBS movements are assumed to be negligible. The determination of the sojourn times of the MBS is calculated by the help of linear programming (LP) methods. The LP solution maximizes network lifetime subject to balanced energy consumption constraints. It is proved through simulations that the use of MBSs maximizes network lifetime than stationary sinks and also it is observed that maximum lifetime solutions are achieved by non-uniform sojourn time distributions among grid points depending on the shape of the deployment area.

2.2 Mobile Data Collector (MDC)-Based Solutions

An MDC is a mobile sink that visits individual sensor nodes. Each sensor node buffers information in it until the MDC visits the nodes and downloads all its information over a single hop wireless transmission. According to the mobility patters of the MDCs [5] existing proposals can be categorized:

- Random Mobility: MDCs move in random patters as proposed in [6].
- Predictable Mobility: An MDC's movement pattern is known as stated in [7].
- Controlled Mobility: An MDC's movement is actively controlled in real time, as proposed in [8].

2.2.1 Data Mules

In its first introduction [6], the MDC is referred to as Data Mules. In this proposal, the sensor node stores the data until an MDC opportunistically approaches the nodes and collect the data from the node through direct communication range. Accumulated data is then transferred to a wireless access point. The performance of Data Mules proposal is evaluated using a Markov model based on a two-dimensional random walk mode for Mules, and the effect of buffer sizes, number of access points, and number of Mules on data loss rate is investigated. The message transfer delay is not upper-bounded as the trajectory of MDC's in [6] is random.

2.2.2 Predictable Data Collection

This proposal is given in [7], where it is stated that the data from the sensors is collected by the vehicles that passes nearby. Sensors are assumed to know the trajectory of the MDCs and the sensors can predict the time of data transfer. Based on the predicted data transfer time, the sensors become active at the time of data transfer, otherwise it sleeps until the time of data transfer arrives to save its energy. A queuing model is utilized in [7] to accurately model the data collection process. Using this queuing model, the success rate of power consumption and data collection are analysed and it is found that by implementing predictable MDC can save energy in Wireless Sensor Networks.

2.2.3 Mobile Element Scheduling

Sensors may generate data at different rates. This behaviour becomes more prominent when data collection is performed at different events. Data loss happens when data are not collected by the MDCs before the sensor node buffer overflows. A proposal called Mobile Element Scheduling (MES) in [8] states that an MDC called mobile element (ME) is scheduled in real time in such a way that the ME will visit the sensor nodes before its buffer overflows. The MES problem is proved to be NP complete and a heuristic solution called Earliest Deadline First (EDF) is proposed in [8] along with its two variants. The EDF solution states that the ME will visit the sensor node which has the nearest deadline of buffer overflow than other nodes. However, EDF suffers from high data loss as in the case of more sensor nodes having consecutive deadlines separated by far distances from each other. To counter this drawback of EDF another variant of EDF called Medium Weight Sum First (MWSF) algorithm is proposed where it considers both the overflow deadline as well as distances between nodes in determining the schedule for visit.

2.3 Rendezvous-Based Solution

Rendezvous based solution is an amalgam of MBS and MDC based solutions. When Wireless Sensor Networks are comprised of in a partition of isolated networks, generated data is accumulated by a sensor buffer in a partition until they are relayed to an MDC. This method can be applied in connected networks to reduce communication node and energy consumption. Proposed solutions that state collection of data by mobile devices from designated sensor nodes belongs to the class of rendezvous based solutions. As in MBS based solutions, data are relayed to mobile devices through multiple hops and like MDC based solutions where data are buffered long enough in sensor nodes before being relayed to mobile devices.

2.3.1 Relayed Data Collection

In [5], a proposal stated that an autonomous mobile router (MDC) is used to collect data fro sensor nodes. Here MDC traverses a linear path and transfers data from the sensors when it comes in range with the sensor nodes. Other nodes which does not come inside the communication range, buffer its data to the nearest node to the MDC to be transferred. Through a tree building initialization phase, all the nodes determine whether it can come in direct contact with the MDC or not. If a node determines that it will never come in direct contact with the MDC, then it discovers the nodes through which it can relay its data in shortest paths before the data gets buffered. Adaptive algorithms are proposed in [5] where speed of MDCs are adjusted in such a way that the speed of an MDC will slow down in order to collect more amount of data from the nodes and will move faster when there are no nodes in range. The algorithm provides best effort service and does not guarantee lossless data transfer. The relayed data collection approach is extended in [9] to allow multiple MDCs to follow parallel linear paths in deployment area. A load balancing algorithm is also introduced to distribute the work among MDCs.

2.4 The PBS Algorithm

The PBS algorithm computes ME trajectory by considering the knowledge of the data generation rates and the location of the sensors. It states that any consecutive visit to a node n_a having buffer overflow time o_a should be at most o_a time apart. To achieve this, PBS algorithm computes ME trajectories in two phases. In the *partitioning phase*, the nodes are grouped in such a way that all the nodes in a group have the same buffer overflow time and are closely located. In the *scheduling phase*, the trajectories inside groups are computed and then concatenated to form a complete trajectory. The minimum speed of MEs is determined based on the complete trajectory length. It is guaranteed that if the ME moves with the computed minimum speed then no buffer overflow occurs in any node.

The partitioning of nodes into groups is accomplished with a two-step process. In the first step, all nodes are grouped into bins Bi, $1 \le i \le M$, such that the minimum overflow time o^*_{i+1} in B_{i+1} is twice the minimum overflow time o^*_i in B_i. Although every bin B_i has nodes with different overflow times, we assign the minimum overflow time o_i* to all nodes in that bin. Consequently, we can treat all nodes in the same bin equally without violating the overflow conditions. In the second step, nodes in a bin Bi are partitioned into 2^{i-1} sub-bins $B_i^{\ j}$, $1 \le j \le 2^{i-1}$, using a 2d tree algorithm such that nodes in the same sub-bin are located close to each other.

The detailed description of the PBS algorithm and detailed simulation results can be found in [10].

2.5 The MRME Algorithm

The main objective of PBS algorithm is to transfer data before the sensor buffer overflow occurs. It may also need to transfer urgent messages along with regular data to the ME. So the urgent messages need to be transmitted to the ME within given delay bounds, say in Δ amount of time. Here, we introduce the MRME algorithm for timely delivery of infrequent urgent messages along with regularly generated data at the sensor buffers.

The basic idea of the MRME solution is to relay UMs to other sensors that are guaranteed to be visited in $\Delta - T_{tx}$ amount of time, where T_{tx} is the time spent to relay information from its source to the sensor where it will be picked up. If a sensor n_a has an overflow time $o_a \le \Delta$, the UM is guaranteed to be delivered to the ME by its deadline. If $o_a > \Delta$, three possibilities exist to guarantee on time delivery of the UM. The first option is to reduce the overflow time of n_a artificially such that the new overflow time $o^{new}_a = \Delta$. The second option is to find another sensor n_b with overflow time $ob < \Delta - T_{tx}$, where T_{tx} is the data relay time between n_a and n_b. The third option is to use a combination of the former two: find another sensor n_b and update its overflow time as $o^{new}_b = \Delta - T_{tx}$.

2.6 Comparison of Mobility-Based Communication Proposals

The MBS based communication proposal aims to increase the lifetime of the Wireless Sensor Network by minimizing the message latency through multihop routing of data from the nodes to the sink. Multihop communication requires no long term buffering of data and consumes highest energy due to relay of third party information to the sink. Mobility is controlled by different algorithms in the deployment field. Among three approaches of MBS proposal, the performance of *base station relocation* and *joint mobility and routing* does not have any dependencies on MBS speed while *move and sojourn* approach requires instant movement of the MBS.

The MDC approach proposes the sink node to visit the sensor nodes individually and collect the data stored in the buffer of the nodes. This solution is appropriate for sparsely deployed sensor networks where sensor lifetime is the primary concern. It demands the collected information should be of least significance to real time data as delays can be unpredictable. Since, no third party information is relayed through the nodes; energy consumption is less and requires large buffer sizes to store data until delivery. The energy savings of sensor nodes is compromised by the fast movement of the MDC to avoid loss of data due to buffer overflow during the collection process. MES and PBS control the movement of the MDC and among the existing proposals; PBS controls the MDC movement more efficiently as it guarantees no loss of data if the MDC moves with the calculated minimum speed.

On the other hand, Rendezvous based solution adapts both the properties of MBS and MDC based solutions. The information of different sensor nodes are collected and stored in buffers at specific nodes which in turn relays those information to the mobile sink upon arrival. Hence, both multihop communications as well as long term buffering are required in this approach. As a result, this approach shows medium message delays and medium platform mobility. The Relayed Data Collection approach of Rendezvous based solution can be used in fixed bus routes. The MRME solution utilizes PBS algorithm with MDC based solutions for relaying regular generated data. However, MRME uses rendezvous based principles to relay urgent messages. Hence, it requires much higher speed for mobile device. A comparison chart is depicted in Table 1.

Table 1. Comparison of mobility-based communication proposals

Class	Algorithm	Multihop commun.	Long-term buffering	Mobility	Message latency	Algorithm execution	Platform mobility	Energy consumption
MBS	Base Station Relocation	Yes	No	Controlled	Low	Online	Low	High
	Joint Mobility and Routing	Yes	No	Controlled	Low	Offline	Low	High
	Move and Sojourn	Yes	No	Controlled	Low	Offline	Very High	High
MDC	Data Mules	No	Yes	Random	High	Offline	High	Low
	Predictable Data Collection	No	Yes	Predictable	High	Offline	High	Low
	MES	No	Yes	Controlled	Medium	Online	High	Low
	PBS	No	Yes	Controlled	Medium	Offline	Medium	Low
Rendezvous	Relayed Data Collection	Yes	Yes	Controlled	Medium	Online	Medium	Medium
	MRME	Yes	Yes	Controlled	Medium	Offline	High	Low

3. REAL TIME PERFORMANCE ANALYSIS FOR WIRELESS SENSOR NETWORKS

In mission-critical system, O-TDMA scheme based on TDMA protocol and a real-time performance analysis method based on WCAU (the worst case achievable utilization) are analysed. Analytical proof that O-TDMA has better performance than other schemes is given. We consider a network composed of multiple sensor nodes and one sink node. Each sensor node periodically sends its acquired data to the sink node, as shown in Figure 1.

We assume that a time division multiple access (TDMA)-based medium access control (MAC) protocol is implemented. In TDMA protocols, time is divided into periodic MAC frames, and each MAC frame comprises multiple time slots. Each sensor node is allowed to transmit packets in its own allocated time slots in each MAC frame so that no collision can occur. The sink node broadcasts a control packet that contains the time slot information at the beginning of each MAC frame. We consider that the control packet can be received by the sensor nodes in a single hop, and that other sensor nodes in multi hops can receive the control packet by multi one-hop-retransmission. In each time slot, only the sending and receiving nodes are kept awake while others stay in the sleeping state, which minimizes energy consumption. These assumptions mentioned above can be shown in Figure 1.

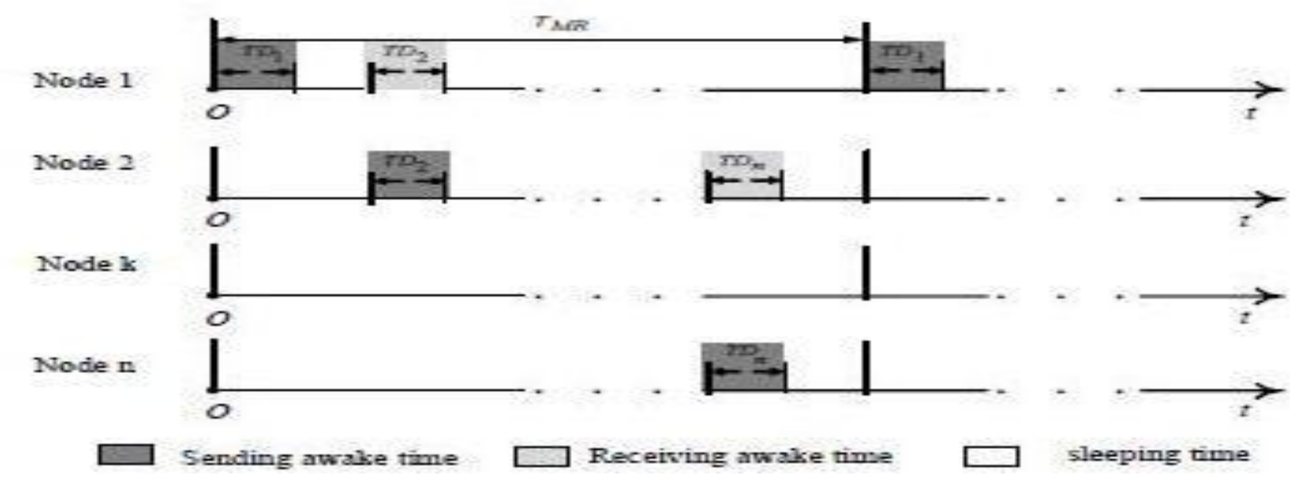

Fig 1: Time slot bandwidth allocated by each node for TDMA-based MAC layer in Wireless Sensor Networks TDi denotes the time slot bandwidth allocated by node i. T_{MR} denotes the maximum expected full slot cycle

Message generated in the Wireless Sensor Networks at run time may be classified as either synchronous messages or asynchronous message. We assume that there are *n* real-time message streams of synchronous messages marked $S_1, S_2, \ldots, S_n$ in the Wireless Sensor Networks. These streams form a message set *M*, formally denoted as:

$$M = \{S_1, S_2, \ldots, S_n\} \quad (1)$$

We describe the message streams S_i as follows:

- Message source node s_i : which denotes the resource node for steam S_i .
- Message sink node d_i : which denotes the destination node for steam S_i .
- Message inter-arrival time P_i : which is the message *Si* generating period, for non periodic message, which represents the minimum inter-arrival of the message.
- Message steam length C_i : which denotes the time for the transmission of steam S_i , including the total length of the protocol-specified fields – information field, check field and preamble.
- Maximum allowed message delay D_i. for the single hop message, we assume that is equal to the P_i. Each message stream

  $$S_i = (s_i, d_i, C_i, P_i, D_i) \quad (2)$$

  The utilization factor Ui, representing the load requirement of Si to the network, is defined as:

$$U_i = C_i / P_i \quad (3)$$

Hence, the utilization, U, of a message set M is defined as the sum of the utilization factors of all the streams:

$$U(M) = \sum_{i=1}^{n} U_i \quad (4)$$

3.1 Transmission Constraints

The bandwidths allocated to the nodes should satisfy both *protocol constraint* and *deadline constraint* in order to guarantee message deadlines for the entire message set.

3.1.1 Protocol Constraint

T_{MR} denotes the maximum expected full slot cycle. We denote the portion of T_{MR} unavailable for transmitting the synchronous messages by α, which comprises overheads of propagation delay, synchronization and negotiation. The sum of TD_i must meet the following conditions:

$$\sum_{i=1}^{n} TD_i \le T_{MR} - \alpha \quad (5)$$

Where, TD_i denotes the time slot bandwidth allocated by node *i*.

3.1.2 Deadline Constraint

Let *X* (t) *I* be the minimum amount of time available for node *I* to transmit its messages during any time interval of length *t*. It must be ensured that the *X* (*t*) *I* is long enough for each stream S_i to transmit it during I maximum allowed message delay D_i . That is:

$$X_I(D_i) \ge C_i \qquad (i=1,2,\dots,n) \quad (6)$$

3.2 Bandwidth Allocation Schemes

The bandwidth allocation algorithm plays a very important role to meet the real-time constraints of message set. If the message set is under the assumption of formula (1) and (2), in the general sense, we denote by *f* the scheme to decide the TD_i, which can be represented as:

$(TD_1, TD_2, \dots, TD_n) = f(C_1,C_2,\dots,C_n,P_1,P_2,\dots,P_n,D_1,D_2,\dots D_n,T_{MR})$

3.3 Worst Case Achievable Utilization

The worst case achievable utilization U^*_A of a scheme is the least upper bound of its achievable utilization factors where U_A is an achievable utilization of the scheme. The *WCAU* is used to evaluate the performance of the schemes. Intuitively, it is preferable to select a scheme with a high U^*_A.

We denote by *f* * the given allocation scheme *. All kinds of *f* * form the set *F*. For a common time slot bandwidth allocation scheme *f* *, the corresponding time slot bandwidth allocated is denoted as TD^*_I *and* the minimum amount of sending time available during D_i is $X^*_I(D_i)$.

3.4 Examples and Simulation

We assume four original message sets (denoted by M_1', M_2', M_3', M_4') which has multi hop message respectively. Therefore, we transform these sets into the ones with only one hop message. The four transformed message sets are denoted by M_1, M_2, M_3, M_4 and listed respectively from Table 3 to Table 6. For instance, M_1' which comprises S_1 $(1,4,C_1,P_1,D_1)$ (h=1). $S_2(2,4,C_2,P_2,D_2)$ (h=1), $S_3'(3,4,C_3',P_3',D_3')$ (h=2), can be transformed into M_1, which comprises $S_1(1,4,C_1,P_1,D_1)$ (h=1), $S_2(2,4,C_2,P_2,D_2)$ (h=1), $S_3(3,2,C_3,P_3,D_3)$ (h=1), $S_4(2,4,C_4,P_4,D_4)$ (h=1).

Table 2. Time slot bandwidth allocation scheme

Bandwidth Allocation Scheme	TD_i Allocated By Scheme	WCAU
B-TDMA	$TD_i = (T_{MR} - \alpha)/n$	$(1-\tau)/(3n-(1-\tau))$ *
F-TDMA	$TD_i = C_i$	0
P-TDMA	$TD_i = \frac{C_i}{P_i}(T_{MR} - \alpha)$	0
NP-TDMA	$TD_i = \frac{C_i/P_i}{U}(T_{MR} - \alpha)$	$(1-\tau)/3$
O-TDMA	expression (13)	$\ge (1-\tau)/3$

Table 3. Bandwidth allocations for message set m_1

Message Parameters				Bandwidth(TD_i) allocated by				
i	C_i	P_i	D_i	*B-TDMA*	*F-TDMA*	*P-TDMA*	*NP-TDMA*	*O-TDMA*
1	90	304	304	25	90	29.6	49.8	43
2	60	304	304	25	60	19.8	33.4	28
3	16	320	320	25	16	5	8.4	5.4
4	16	320	320	25	16	5	8.4	5.4
Protocol constraint met ?				Y	N	Y	Y	Y
Deadline constraint met ?				N	Y	N	Y	Y
Real-time transmission ?				N	N	N	Y	Y

Table 4. Bandwidth allocations for message set m_2

Message Parameters				Bandwidth(TD_i) allocated by				
i	C_i	P_i	D_i	*B-TDMA*	*F-TDMA*	*P-TDMA*	*NP-TDMA*	*O-TDMA*
1	60	270	270	25	60	22.2	35	30
2	72	270	270	25	72	26.6	42.2	36
3	20	280	280	25	20	7.14	11.3	10
4	20	280	280	25	20	7.14	11.3	10
Protocol constraint met ?				Y	N	Y	Y	Y
Deadline constraint met ?				N	Y	N	Y	Y
Real-time transmission ?				N	N	N	Y	Y

Table 5. Bandwidth allocations for message set m_3

Message Parameters				Bandwidth(TD_i) allocated by				
i	C_i	P_i	D_i	*B-TDMA*	*F-TDMA*	*P-TDMA*	*NP-TDMA*	*O-TDMA*
1	30	170	170	25	30	17.6	30.2	30
2	50	190	190	25	50	26.4	45.2	50
3	8	110	110	25	8	7.2	12.2	8
4	8	110	110	25	8	7.2	12.2	8
Protocol constraint met ?				Y	Y	Y	Y	Y
Deadline constraint met ?				N	Y	N	N	Y
Real-time transmission ?				N	Y	N	N	Y

Table 6. Bandwidth allocations for message set m_4

Message Parameters				Bandwidth(TD_i) allocated by				
i	C_i	P_i	D_i	*B-TDMA*	*F-TDMA*	*P-TDMA*	*NP-TDMA*	*O-TDMA*
1	92	330	330	25	92	27.8	32.2	31
2	106	330	330	25	106	32.2	37.2	38
3	42	320	320	25	42	13.2	15.2	14
4	42	320	320	25	42	13.2	15.2	14
Protocol constraint met ?				Y	N	Y	Y	Y
Deadline constraint met ?				N	Y	N	N	Y
Real-time transmission ?				N	N	N	N	Y

In simulation, we assume that T_{MR}=100, and α = 0. Both *P-TDMA and B-TDMA*'s real-time performance are worst, since no real-time transmission can be supported for all four given message sets. Among all the 4 tables, only the *O-TDMA* scheme can meet the real-time requirements (protocol constraint and deadline constraint), and is superior to the other schemes, which is consistent with the before mentioned analysis under *WCAU* criterion.

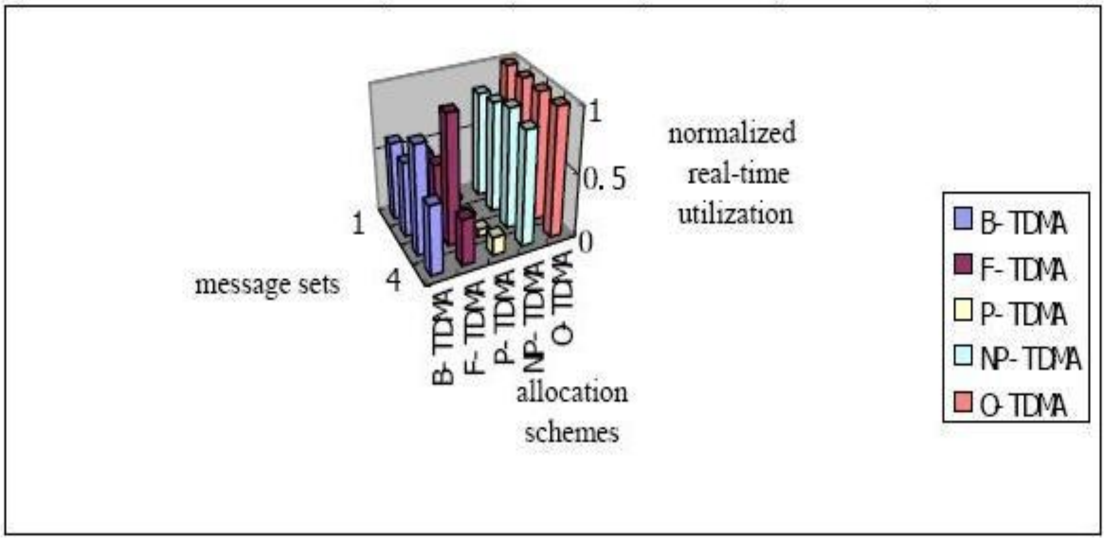

Fig 2: Simulation comparison of five bandwidth allocation schemes

Finally, the simulative results showed the real-time performance comparison among the 5 schemes mentioned in Figure 2. The goal we pursuit is to utilize the real-time bandwidth efficiently and properly. The real time utilization is defined as the number of the messages that meets the real-time constraints within a time unit.

4. PROPOSED: REAL TIME MOBILE COMMUNICATION IN WIRELESS SENSOR NETWORKS

After detailed analysis through the discussed chapters in this project, we can determine the optimal possible solution to implement mobility in communication in Wireless Sensor Networks. The Rendezvous based solution implemented with Relayed Data Collection algorithm is found to be the most appropriate in terms of enhancing the connectivity and energy efficiency in Wireless Sensor Networks. This algorithm makes the solution capable to handle Multi hop communication and Long-term buffering unlike the MBS and MDC based solutions respectively. It works under controlled mobile environment in medium mobile platform. Although its message latency and energy consumption is medium compared to the MBS and MDC based solutions, it is optimal to implement in mobile environment.

On the other hand, the optimal time slot bandwidth allocation scheme TDMA (O-TDMA) has been proved as the optimal solution for hard real time communication in Wireless Sensor Networks. The simulation results discussed in this chapter claims that O-TDMA technology has met the protocol constraint, deadline constraint and real time transmission parameters unlike the other allocation schemes like B-TDMA, F-TDMA, P-TDMA, NP-TDMA which failed to meet the three parameters. Also it is proved that O-TDMA has better index in WCAU than other allocation schemes. Hence, to have an efficient and effective Wireless Sensor Network, we can implement the O-TDMA allocation scheme coupled with Relayed Data Collection algorithm of Rendezvous based solution to achieve an efficient real time communication with enhanced connectivity and energy efficiency within a mobile Wireless Sensor Network.

5. CONCLUSION AND FUTURE WORK

In this paper presentation, we have compared the different data transfer methods for Wireless Sensor Networks in mobile platform and tabularized the comparison chart. By analyzing various methods related to data transfer in Wireless Sensor Networks, we have drawn an optimal solution – Rendezvous based solution implemented with Relayed Data Collection algorithm by tracking and meeting several performance parameters. On the other hand, real time communication is the need of the hour to process and analyze urgent data captured by the sensor nodes for immediate results. Hence, among the different bandwidth allocation schemes, the optimal bandwidth allocation scheme – O-TDMA has met the efficiency factor for real time data transfer in Wireless Sensor Networks according to the guideline of the worst case achievable utilization. In the end, we proposed a scheme to combine the efficiency of O-TDMA with the capabilities of the Rendezvous based data transfer method implemented with Relayed Data Collection algorithm, such that data can be transferred from the isolated sensor nodes to the sink in real time on mobile platform.

Among the future work, we plan to reduce the message latency, increase the platform mobility and energy efficiency of the Relayed Data Collection algorithm and the energy constraint can be taken into consideration for the O-TDMA allocation scheme for better overall performance by our proposed scheme.

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