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A Dynamic Topology Management in a Hybrid Wireless Superstore Network

Shankaraiah and Pallapa Venkataram
Protocol Engineering Technology Unit, Electrical Communication Engineering
Indian Institute of Science, Bangalore, India. Email:{shankaraiah,pallapa}@ece.iisc.ernet.in

Abstract—with the development of large scale wireless networks, there has been short comings and limitations in traditional network topology management systems. In this paper, an adaptive algorithm is proposed to maintain topology of hybrid wireless superstore network by considering the transactions and individual network load. The adaptations include to choose the best network connection for the response, and to perform network Connection switching when network situation changes. At the same time, in terms of the design for topology management systems, aiming at intelligence, real-time, the study makes a step-by-step argument and research on the overall topology management scheme. Architecture for the adaptive topology management of hybrid wireless networking resources is available to user's mobile device. Simulation results describes that the new scheme has outperformed the original topology management and it is simpler than the original rate borrowing scheme.

Index Terms— Hybrid Wireless Network, Superstore, Transaction Sensitive Level (TSL), Topology Management

I. INTRODUCTION

With the increment in the scope and the increase in complexity of fourth generation wireless networks, network topology has become an important topic for study. The topology management of hybrid wireless networks is sure to be a new hotspot for research. It is evident that the traditional static topology management schemes cannot adapt to the topology structure of the next generation wireless network.

Different integrated wireless technologies are used for different purposes. GSM [1], [2] and WiFi [3] are getting more attention because of their capability in providing wireless connectivity. Integrating GPRS and WiFi gives both ubiquitous coverage and support high data rate in strategic locations (Superstore, campuses, office, airports, hotels, coffee shops etc.).

When WiFi and GPRS networks are integrated, the cellular operators are able to meet some requirements for 4G services. This would allow them to provide high quality data services which can be perceived as 4G-like services. In this paper, an integrated network of GSM and WiFi covering the same service area is considered for a superstore business. Typical hybrid wireless superstore network architecture is shown in Fig.1.

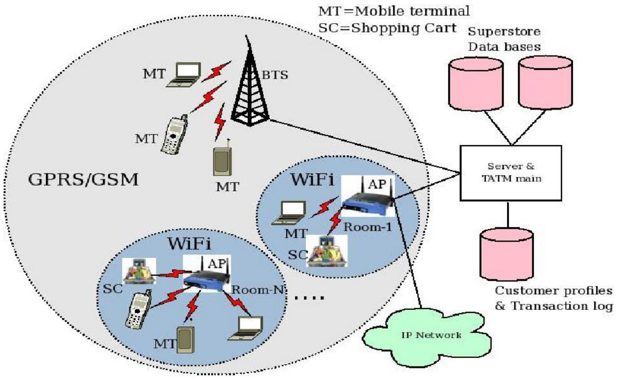

Fig 1: Superstore hybrid wireless network

Hybrid wireless communication networks are evolving wireless networks architecture developed to help extending the actual radio coverage of the wireless networks beyond their actual range. This can be achieved by integrating different wireless network technologies along with a wired network. The problem of topology management for such hybrid wireless networks is very difficult to solve because of insufficient network resources, overloading on one networks and mobility of the customer. In such hybrid wireless network architecture, communication takes place between the mobile terminal (MT) and the Base Transceiver Stations (BTS) or Access Points (APs). Several kind of wireless networks may be merged logically to form larger wireless network.

Mobility of the customer leads to constant change in the location and the network conditions. Mobile devices with multi-interface network switch between the networks during data transfer and other network activities. And further when a single network gets crowded, the network can select best network in the same range and carryout data transmission in that network. To ensure that the handoff is successful topology management is essential.

A superstore *transaction* [4] corresponds to one of a finite number of interactive processes between the customer and the superstore server. Each transaction consists of a predefined sequence of operations. Some examples of transactions is listed in Table I.

Among all possible superstore transactions, not all transactions are important for the superstore management. Hence it is wise to manage the transactions traffic which is essential. An efficient method is required to manage the topology of wireless network and for admission control. A topology management scheme for scheduling the superstore transactions based on the gradational importance.

The main contributions of this paper are:

- Reduce the load on one network
- Minimize the energy consumption of the transmission of data to server.
- Enhance the QoS and provides less congested cells for each critical transaction.
- Distribute load in the hybrid wireless superstore environment by knowing topology
- Multi-mode users can connect to the best points of attachment and best QoS offering by HWNs
- Different network types are linked together and they can provide wider ranges and higher QoS than in homogeneous wireless networks.
- Minimize the necessary resource through the appropriate access network.

In this paper, we present a topology management scheme in a hybrid wireless network to improve the QoS of data transfer of each transaction request, save energy of the mobile terminals and prolong the network life time. A wireless topology management that manages the activities and features of a wireless network connection. It may control the process of selecting an available access points, authentication and associating to it and setting up other parameters of the wireless connection.

The rest of the paper is organized as follows. Section II describes the some of the related works. Section III discusses the working of hybrid wireless superstore environment. Section IV illustrates the proposed transaction-aware adaptive topology management along with the algorithms. Section V gives the analytical model of the proposed work. Section VI explains the simulation results and finally, the paper concludes in Section VII.

II. RELATED WORKS

The topology management algorithms have been proposed to maintain network connectivity while reducing energy consumption and improving network capacity in hybrid wireless superstore networks.

Many new challenges have emerged in the system design and analysis of wireless networks. Energy efficiency and network capacity [13] are among the most fundamental issues. Various topology control algorithms have been proposed to address these two challenges.

Lot of research has been carried out on hybrid wireless network integration. Mobile IP based vertical handoff [5] proposed an integrated wireless networks like WLAN and GPRS. The authors have implemented a vertical handoff scheme that allows a mobile user to roam between different wireless networks in a manner that is completely transparent to applications and disrupts connectivity as little as possible.

Mobile IP binding update extension [6] can support multiple interfaces and data flow control.

Ramanathan et al. [7] presented two centralized algorithms to minimize the maximal power used per node while maintaining the (bi) connectivity of the network. They introduced two distributed heuristics for mobile networks. Both centralized algorithms require global information, and thus cannot be directly deployed in the case of mobility. And the distributed heuristics cannot guarantee the preservation of network connectivity.

Borbash and Jennings [8] proposed to use RNG for topology initialization of wireless networks. Based on the local knowledge, each node makes decisions to derive the network topology based on RNG. The derived network topology has been reported to exhibit good performance in terms of power usage, interference, and reliability.

Most existing topology control algorithms [12] assume homogeneous wireless nodes with uniform transmission ranges. When directly applied to heterogeneous networks, these algorithms may render disconnectivity. Hence we give several examples to motivate the need for new topology management algorithms in heterogeneous networks.

In [14], the authors proposed Local Minimum Spanning Tree (LMST) for topology control in homogeneous wireless multi-hop networks. In this algorithm, each node builds its local minimum spanning tree independently and only keeps on tree nodes that are one-hop away as its neighbors in the final topology. Authors proved that: 1) the topology derived under LMST preserves the network connectivity; 2) the node degree of any node in the resulting topology is bounded by 6; and 3) the topology can be transformed into one with bidirectional links (without impairing the network connectivity) after removal of all uni-directional links. The results show that the LMST can increase the network capacity as well as reduce the energy consumption.

Gupta and Kumar [13] showed that the traffic carrying capacity of the entire network is maximized if each node uses the smallest power required to maintain the network connectivity. Authors also describe that under what conditions a wireless transmission over a sub channel is received successfully by its intended recipient. They are considered two types of networks, Arbitrary Networks, where the node locations, destinations of sources, and traffic demands, are all arbitrary, and Random Networks, where the nodes and their destinations are randomly chosen for their simulation.

The authors in paper [15] presented a work on Connection Management Agent (CMA) concentrated on multiple wireless access networks that are available to one single user device, in which the accesses are all infrastructure wireless connections like WLAN, GPRS and UMTS. The research basically shares the common idea, but focuses on a “hybrid” access system where available connections include both infrastructure and ad hoc.

III. A HYBRID WIRELESS NETWORK IN A SUPERSTORE ENVIRONMENT

We consider a superstore as a large departmental self service store which sells wide variety of food and house hold materials. The superstore consists of GSM and WiFi Networks integrated together in a superstore environment for accessing the commodities information, location, maps, price of the products, purchase, etc. WiFi technology is designed for high speed transmission and enables longer range of connection. WiFi technology has been deployed for public access to create hotspots in places like superstore, hotels, airports and campuses. Superstore architecture of WiFi and GSM can take advantage of the complementary characteristics of those two technologies and provide a total solution for hybrid Wireless communication environment.

In a hybrid environment, the WiFi is used to get stock details of shelves, to identify the category of products and their place of availability in the superstore. The system uses the RF-ID technology for monitoring and identification of goods in a shopping cart. Database servers, cash registers and central servers are connected to the superstore LAN. In a superstore, the customer is able to view and modify their shopping list which is automatically generated and one can place an order through one's mobile phone, PDA/ Laptop, etc. In order to provide anytime and anywhere connectivity over the hybrid wireless networks, a mobile terminal, which has multi-interfaces, is able to handover among the different access technologies.

To improve the performance of a business critical transaction by reducing delay involved and to reduce the load on one network while accessing the database and accommodating more user transactions at peak time, efficient topology management and admission control are indispensable.

Each shopping cart in the superstore is equipped with an electronic system based on a specialized computer with a display. The shopping cart computer has an RF-ID sensor to take stock of goods in the shopping cart. As soon as the user picks the products from shelves and placed in shopping cart, the RF-ID reader notifies to the computer automatically. The shopping cart computer will send all the details of the shopping basket to the server via the WiFi network.

Most of the time, the customers encounter unpredictable delays in accessing the superstore database. Also customers come across large queues at the billing service counters. When the customers are in hurry, they have to get service without delay. This paper tries to solve some of the above said problems for a customer in the superstore by efficient utilization of available bandwidth.

A. Superstore transactions

As defined earlier, a superstore transaction corresponds to an interaction between the customer and the superstore server. An example of a typical superstore transaction [4] is a user purchasing a food product by connecting to the superstore server through a hybrid wireless network. The purchase of a food product consists of several transactions. A user intending to purchase a food product typically logs into the superstore server, checks its details, expiry date, contents, price, offered discount, if any, select the preferred food products, picks the number of quantities he/she wants to purchase, and then place them in the shopping carts, and provides credit card details to finally purchase the food product and receive the confirmation.

To successfully complete this transaction, the connections must be established between the participating entities and adequate resources must be allocated to various transactions at different instants. If these transactions are carried out in a superstore hybrid wireless network, the connections have to be established between the involved entities and the necessary resource have to be allocated for completion of these transactions.

Some transactions may have strict restricted delay and response time requirements. Therefore, the QoS support for superstore transactions must address the requirements of variable resources, bounded delay, and response time. Providing resources to superstore transactions is a complex issue because of the mobility of users, handoffs during ongoing transactions, resource variability of transactions, etc.

IV. TRANSACTION-AWARE TOPOLOGY MANAGEMENT(TATM) IN A HYBRID WIRELESS SUPERSTORE ENVIRONMENT

The architecture of the TATM in a Hybrid Wireless Superstore Environment management scheme is shown in Fig. 3. We discuss the functioning of the TATM by describing each of its components and their functions.

The customers start the communication by sending the transaction through the corresponding network. If mobile device is equipped with multiple wireless connections,

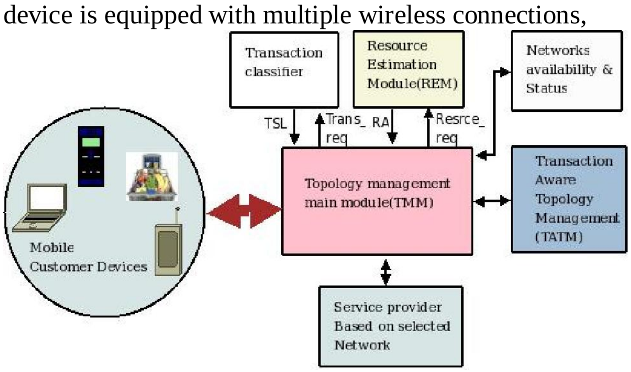

Fig 3: Architecture of transaction-based topology management in a hybrid wireless superstore environment.

then the best available connection will be selected by the server for the creation of response to the transaction. A default priority in the architecture is to choose WiFi connection as long as possible. This is because in general WiFi connection is free with better bandwidth than infrastructure connection like GSM/GPRS. During data transfer operations, the mobile devices may move into or out of the overlapping area of hybrid wireless access area. In this case the connection used by the channel can be seamlessly switched without necessarily being perceived by the customers, to ensure that the best connection is always used at any time.

Transaction classifier

The main objectives of this module is to find the transaction sensitivity level(TSL) for a given transaction. The TSL is analyzed based on the parameters: type of data involved in each transaction, time of operation, type

TABLE. I
Transaction sensitivity level and transaction categorization

Transaction Sensitivity Level	*Service types*	*Examples Transactions*
0	**No Profit service.**	Product general information browsing, downloading free samples, browsing low value products details, etc.
1	**Low Profit service.**	Placing low volume orders, requesting account statement, Request for maps of superstore where require items are placed, Request for technical information, etc.
2	**Moderate Profit Service.**	Placing high volume orders, making macro payments, requesting purchase bills, requesting private information, making account transfers, etc.
3	**High Profit Service**	Financial transaction, large amount billing, making large account transfer, making large advance payments, authentication of customer, etc.

of device used, location of operation, type of transaction, mobility and type of traffic generated by each transaction. This analysis produces the TSL ranging from 0 to 3. A set of transactions with different sensitivity levels is shown in the Table I. The function of transaction classifier is given in the Algorithm. 1.

Algorithm 1 Transaction classifier module

begin
Accept the transaction details from TATM main.
Let **Op req** is the operation requested by transaction T.
if Op req is "superstore transaction" **then**
Let **TYPE** is the type of superstore service to be used.
  if TYPE is NO Profit Service **then**
  TSL=0;
else if TYPE is Low Profit Service **then**
  TSL=1;
else if TYPE is Moderate Profit Service **then**
  TSL=2;
else if TYPE is High Profit Service **then**
  TSL=3;
end if
end if
Pass TSL of transaction to *TATM main*.
End

Resource Estimation Module (REM)

The REM module estimates the resource requirement of each incoming new transactions. If it is a handoff transaction, it assigns the value as specified in the previous network. In any commercial transaction, request transactions can be of few kilobytes, where as the response transaction can be of multiple megabytes in size. These characteristics create very challenging demands upon the network, which must accommodate the associated bandwidth and latency effects. Total number of transactions is largely independent of the users. The total number of transactions to complete a business process is entirely a function of process complexity.

A transaction can vary widely in terms of sensitivity, power, buffer, bandwidth required and acceptable latency depending on the type of the transactions being executed. The resource required is calculated upon making the following assumptions.

- All the packets per transaction have the same size.
- The wireless channel is error free channel.

The estimation of bandwidth requirement for a transaction is given as:

$$b_i = \frac{8 * K * M}{KP + T} \text{ Bits/Secs} \quad (1)$$

Let $Buffer_i$ be the number of byte of memory require for each transaction. The estimation of memory requirement for a transaction is given as:

$$Buffer_i = \frac{K * M}{1000} \text{ Kbytes} \quad (2)$$

Where
K = No. of packets per transaction in any one direction.
M= No. of bytes per packet in any one direction.
P = One way network latency per packet.
T = The amount of time a user needs between successive transaction executions. The working of REM is given in the Algorithm 2.

Network availability and status

This module periodically selects the best network among the available networks in the vicinity of the mobile terminals. When a customer moves to next location, it will choose the best network that provides the best QoS among the available APs or BS. The working of network availability checking module is given in the Algorithm 3.

Transaction-Aware Topology Management Module (TATM)

This module is to schedule the transaction response based on the estimated resource required for each transaction. At regular intervals of time, the system collects all transactions arrival in that interval, classifies them into different categories based on the sensitivity of operation and queues them in four priority queues. The scheme schedules the highest priority transactions first, keeping the lowest priority transaction pending. If all the highest priority transactions are over, then it continues with next priority level transactions, and so on.

In strict priority scheduling, a queue with a lower priority is scheduled only if all queues with a higher priority are empty. However, this may result in a starvation for low priority transactions. Further, the transmission order of different priority queues (PQs) is based on their priorities. According to [10], [11], 13% of all transactions have the highest two priority TSL (2and 3), 32% have TSL level 0 transactions and remaining 55% in TSL level 1 transactions.

Algorithm 2 Resource estimation module(REM)

---

begin
Accept TDs and TSL $\Leftarrow$ TATM main .
Let **Op req** is the operation requested by transaction Ti.
while Op req is new transaction **do**
Accept *Datasize(V), transaction type(TYPE) and time of operation(t)* from transaction Log(TL).
if Any information require from *TL* **then**
Fetch them from TL.
end if
Estimate the bandwidth, buffer requirement of each transaction
b_{Reg_bw}, Buffer_reg $\Leftarrow$ *REM*(R),Send b_{Reg_bw}, Buffer reg $\Rightarrow$ *TATM main.*
end while
End

Algorithm. 3 Network Availability Checking module(NACM)

---

begin
Accept TDs and TSL $\Leftarrow$ TATM main.
Accept the networks within the vicinity of MT's
Let **NW_Sel_Op_ req** is the network selection operation
requested by transaction Ti.
while NW_Sel_Op_ req is new transaction **do**
Accept *Resource availability of all the networks within the vicinity*.
if Any information require from *AP/BS* **then**
Fetch them from AP/BS.
end if
Resource_ Reg_ MTi= AP1
if Resource _Reg_ MTi $\geq$ BS resource **then**
Resource _Reg_ MTi=BS resource.
else
if Resource _Reg_ MTi $\geq$ AP2 **then**
Resource_ Reg_ MTi = AP2
.....
end if
end if
Resource_ Reg_ MTi $\Leftarrow$ *NACM*(N),Send Resource_ Reg_ MTi $\Rightarrow$ *TATM main.*
end while
End

To avoid the possible starvation of the low priority transactions, we propose a scheduling policy in which older un-serviced transactions which have not been scheduled due to their low priority are automatically upgraded to higher priority levels in the next scheduling session. For this reason, if a older transaction request has a lower priority value, then it will be served even if other newer transaction of higher priority are present in the scheduler. In this way, the scheduler algorithm guarantees an efficient aging mechanism of the requests, according to the transaction level categories. The working of transaction scheduler is given in the Algorithm.4

Service provider module

This module is responsible for providing services based on selected network and assigned resource. This module works as per the information passed by the TATM main module. The function of the service provider is given in Algorithm 5.

TATM main module

The TATM main module coordinates the functions of all the components of the TATM. The transaction received is directed to the transaction classifier to find TSL. It guides the Resource Estimation Module (REM) to estimate the resource requirement of each transaction. It guides the Transaction Scheduling and Topology Management Module (TATM) to allocate resource based on the TSL, type of transaction required. The function of TATM main module is given in the Algorithm 6.

Transaction log

This transaction log is recorded at service provider to maintain the details of all the transactions conducted by the superstore customers. The structure of the transaction log is service dependent, and its contents can be used to estimate the resource requirement of each transaction. Also the maximum and minimum values of resource requirement can be estimated using data size, type of transaction, etc.

V. ANALYTICAL MODEL

Given the mobile user traffic intensity $\tau^t(x, y)$ at the AP_i at time t. The total traffic intensity can be viewed as N separate datasets, where N indicates number of wireless networks (i.e No of APs +BS). The number of traffics at AP_i = {1, 2, 3, ... n_i } where n_i indicates total number of traffics in each cell.

Algorithm 4 Transaction-Aware Topology Management

---

begin
while Not end of customers transactions **do**
Accept the set of transaction {T1, T2, ..., Tm}.
Accept b_{bw_req}, Buffer_reg $\Leftarrow$ *REM* & TSL $\Leftarrow$ TATM main
if any Unscheduled transactions from previous **then**
Schedule all unscheduled transactions with high TSL.
end if
Schedule all highest priority transactions.
if New transaction **then**
if New transaction arrived require BW bi < system

Available BW **then**
11: allocate bi and schedule the transaction
12: **else**
13: **if** New transaction arrived require BW bi > system Available BW **then**
14: Increase the priority level and schedule next.
15: **if** All transactions are over **then**
16: Schedule next highest priority transactions.
17: **end if**
18: **end if**
19: **end if**
20: **end if**
21: **if** All Priority levels are over **then**
22: Increase the priority of the unscheduled transactions
23: Continue with next set of transactions.
24: **end if**
25: **end while**

Algorithm 5 Service provider module

1: begin
2: **while** Not end of customer transaction **do**
3: Accept the Resource requirement from TATM main.
4: Provide service based on allocated bandwidth and Sensitivity of transaction.
5: **end while**

At the superstore server, for each cell, do the following

- Sort ascending each traffic from AP_i , i =1,2,3, ...N,
- In each cell, divide the each traffic into different priority traffic
- Count number of traffics in each priority levels
- Sort traffic in each priority in ascending order of their priority
- Count the number of traffic suggested in each cells, maximum traffic levels and how many traffic can be afford by the Cell.

The probability for total transaction is given by

$$P(N) = \sum_{i=1}^{N} \frac{1}{n_i} = 1 \quad (3)$$

Algorithm 6 TATM main module

1: Begin
2: Collect all transaction in the interval t2-t1.
3: while Not end of customer transaction do
4: Accept the transaction details(TDs), Send TDs $\Rightarrow$ transactionClassifier(TC)(T).
5: if Any request from TC(T) to find TSL then
6: Fetch them from customer.
7: end if
8: TSL $\Leftarrow$ TransationClassifier(T).
9: end while
10: Send TDs and TSL $\Rightarrow$ REM.
11: AcceptDatasize(V),T Y PE and timeofoperation(t) from transaction log(TL).
12: if Any information require from TL then
13: Fetch from TL.
14: end if
15: Estimate the resource requirement of each transaction using V, TYPE, TSL and t;
16: b_{Max_bw}, Buffer_reg $\Leftarrow$ REM(R), Send b_{Max_bw}, Buffer _reg and TSL $\Rightarrow$ TATM.
17: $Sel_{Network}$ $\Leftarrow$ TATM, Send $Sel_{Network}$ $\Rightarrow$ SP.
18: if Customer transaction is end then
19: Disconnect the client session.
20: end if
21: End

The probability for total number of transaction in each cell is given by

$$p(n_i) = \frac{1}{n_i} \quad (4)$$

Where i=1, 2,…. N

The number of users getting resources depends on the number of users entering the networks, available resources and type of transaction to be executed. Let R be the maximum amount of resources available in the hybrid wireless superstore network. These resources should be shared between "n=N" customers for shopping transaction. Each transaction require $R_i = \{r_1, r_2, r_3, r_3, ... r_N\}$ amount of resources. There are m user transaction is available in the superstore at time t. Then probability of rejecting the call is given by

$$P(Max.AvailableR - \sum_{i=0}^{n-1} R_i \leq 0) = P(reject) \quad (5)$$

i.e

$$P(R - \sum_{i=0}^{n-1} R_i \leq 0) = P(reject) \quad (6)$$

The probability of accepting the call is given by

$$P(accept) = 1 - P(reject) \quad (7)$$

The probability of the customer getting resource is P and not getting the resource is 1-P. The probability of ith customer getting the resource is

$$P_i R_i \leq R \quad (8)$$

The total resource utilized by the m customer is given by

$$\sum_{i=1}^{m} P_i R_i \leq R \quad (9)$$

But

$$\sum_{i=1}^{m} P_i = 1 \quad (10)$$

Let λ be the average number of arrival per unit time to the superstore. The number of arrival to superstore is a poison and probability mass function is given by

$$P_X(k) = \frac{e^{-\lambda} \lambda^k}{k!} \quad (11)$$

Where k = 0, 1, 2, 3........

Poisson probability mass function with average number of arrival λ is a good approximation for a binomial PMF with parameters n and p provided λ = n*p, Where n should be very large and probability P should be very small.

$$\frac{e^{-\lambda}\lambda^k}{k!} = \binom{n}{k} P^k (1-P)^{n-k} \quad (12)$$

Where k = 0, 1, 2, 3........

Out of n users k number of users getting the resources and its binomial random variable is given by

$$P_X(k) = \binom{n}{k} P^k (1-P)^{n-k} \quad (13)$$

Hence the probability of success of the customer is given by

$$P(accept) = \binom{n}{k} P^k (1-P)^{n-k} \frac{e^{-\lambda}\lambda^k}{k!} \quad (14)$$

A. Transaction categorization

TABLE II

TRANSACTIONS CATEGORIZATIONS

Transaction Types	*Number of transactions*
1	$\lambda_1.X$
2	$\lambda_2.X$
3	$\lambda_3.X$
…	…
S	$\lambda_s.X$

The transaction categorization is done based on type and importance of that transaction in superstore business applications. Let there be 's' transaction types, N downlink transactions may be distributed between 's' types. Let $S_r (1 \le r \le s)$ be the random variable which counts the number of transactions of type 'r' among the given N transactions. Let λ_r be the average rate of occurrence of each type of transaction and n_r represents the number of transaction of type 's'. The probability of number of downlink transactions in each type is a Poisson and given by

$$P(S_r = n_r) = \frac{(\lambda_r X)^{n_r} e^{-\lambda_r X}}{nr!} \quad (15)$$

The expected value of each type of transaction is given by

$$E(S_r) = \sum_{r \in Type\_s} \lambda_r X \quad (16)$$

We arrange the downlink transactions according to their type. The 's' types of transaction and there are N transactions in the duration X. For simplicity, we are dividing the type of transactions into four levels and distributing all the transactions into four level queues based on their types. We are considered only four levels in order to reduce the complexity of the systems. Let m_0, m_1, m_2 and m_3 be the number of transactions of level 0, level 1, level 2 and level 3. Let M_l be the random variable which indicates number of transactions in each levels. The probability for number of transactions belong to level 'l' is

$$P(M_l = m_l) = \frac{\left(\sum_{r \in level\_l} \lambda_r X\right)^{m_l} e^{\left(\sum_{r \in level\_l} \lambda_r X\right)}}{m_l!} \quad (17)$$

The total average transactions in each level is given by

$$E[M_l] = \sum_{r \in level\_l} \lambda_r X \quad (18)$$

where 'l' is a index value and it can take 0, 1, 2 and 3.

$$N = m_0 + m_1 + m_2 + m_3; \quad (19)$$

B. Resource estimation model

The resource estimation is done only for new transactions but for the handoff transactions previous resource allocation is considered. This algorithm runs at superstore server to estimate the resource requirements of downlink transactions that has been received successfully with a small time interval. The transaction response time can be calculated by knowing the average time required to send one packet from server to destination device in hybrid wireless networks. The receiving time of the response message (rb_i) is used as the packet interval end point. Therefore, the duration of the packet interval time (PIT) is computed by

$$PIT_j = rb_j - st_j \quad (20)$$

Where st_j is the packet interval start time $st_j = t_0$ for i = 0.

The transactions data size (tds) can be calculated by knowing the number packets in each transaction.

$$tds_j = m_j PL \quad (21)$$

Where m_j the number of packets in each transaction and PL is is the packet length. The packet length may vary from 500 to 1500 bytes. Now bandwidth requirements of the j^{Th} transaction can be estimated by using the equation

$$b_j = \frac{tds_j}{(m_j * PIT_j + latency)} \quad (22)$$

for j = 0, 1, 2 ....

Where latency is the minimum delay of the corresponding network. The total bandwidth required by all the transactions in the interval X is given by

$$B_{total} = \sum_{j=1}^{N} b_j \le B \quad (23)$$

The available bandwidth in the networks is given by

$$B_{Available} = B - \sum_{r=1}^{S} b_r \quad (24)$$

Let $Buffer_i$ be the number of byte of memory require for each transaction. The estimation of memory requirement for a transaction is given as:

$$Buffer_i = \frac{K * M}{1000} \text{ Kbytes} \quad (25)$$

Where

K = No. of packets per transaction in any one direction.

M= No. of bytes per packet in any one direction.

P = One way network latency per packet.

T = The amount of time a user needs between successive transaction executions.

Let S_n be the number of each transaction packets sent and S_r be the number of packets received the acknowledgments. Then percentage of packet loss can be estimated in hybrid wireless network is

$$\%\ packet - loss = \left(\frac{S_n - S_r}{S_n}\right)100 \quad (26)$$

Let S_i is the sending time for packet i, and R_i is the receiving time for packet i, then for two packets i and j, inter-arrival jitter $D(i, j)$ may be expressed as:

$$Jitter = D(i, j) = (R_j - S_j) - (R_i - S_i) \quad (27)$$

C. Network availability and status

The main object of this module is to identify all the Candidate Networks from all the available networks and assign them Priority based on available load in the network. A candidate network is the network whose RSS is higher than its threshold value and its velocity threshold is greater than the velocity of mobile terminal. Let $N = \{n_1, n_2, n_3, ...n_k\}$ is the set of available network interfaces. $V_{Th} = \{vt_1, vt_2, vt_3, ...vt_k\}$ is the set of threshold values of velocities for a mobile terminal for the respective networks.

$RSS_{Th} = \{rss_{th1}, rss_{th2}, rss_{th3}, ...rss_{thk}\}$ is the set of threshold values of received signal strengths of respective networks. $RSS_{Diff} = \{RSS_{Diff1}, RSS_{Diff2}, RSS_{Diff3}, ...RSS_{Diffk}\}$ is the set of values of difference between the received signal strength and its threshold value. CN = is the set of all eligible candidate networks into which the handoff can be done. $P = \{0, \frac{1}{k}, \frac{2}{k}, ...\frac{j}{k}, ...1\}$ is the set of priority values for j^{th} network, where j=1,2, ..k. The superstore server get the details of network base station (BS)/AP and MT for the RSS and Velocity respectively at the specified time intervals and the decisions are taken as below to select the candidate networks for handoff : Let the MS is currently in network n_i Then

If $(RSS_i < rss_{thi})$ then For all n_j where j, i are AP/BS

If $(RSS_j < rss_{thj})$ and $(v_i < vt_j)$ then

CN = $CNUn_j$ $RSS_{Diffj} = RSS_j - rss_{thj}$

The priority is based on RSS_{Diffj} where higher the RSS_{Diffj} means higher the priority. It is so because higher RSS_{Diffj} indicate that the MT is more nearer to the BS/AP of that network and hence the MT can stay for more time in the cell of the respective network before asking for another handoff. Thus it makes possible to reduce the unnecessary switch over and improve the overall performance of the application. The priory P is assigned to all the networks as below- Let there are N candidate networks out of k available networks at time t then

For j=1 to k Do

If j is not a candidate network then $P_j = 0$

Else if j is the only candidate network then $P_j = 1$

Else if network is at i^{th} position in an ascending order Sorted set of RSS_{Diffi} then $p_j = \frac{i}{k}$

Using above rule based the Network availability and status, select the eligible networks from the all available networks and assign the priority.

D. Dynamic topology management module(TATM)

This module is responsible to take final decision of selecting a particular candidate networks from a set of candidate networks decided earlier by network availability and status module. A dynamic score DScore is calculated for each network i as below

$$DSscore_i = S_i * P_i \quad (28)$$

Where S_i is the score calculated by the NACM module and P_i is the priority decided by the ND module for the i^{th} network. A candidate networks which has highest corresponding value of DScore is selected as the best network to handoff.

After selecting the network, Scheme schedules the highest priority transactions first, keeping the lowest priority transaction pending. If all the highest priority transactions are over, then it continues with next priority level transactions, and so on. In priority scheduling, a queue with a lower priority is scheduled only if all queues with a higher priority are empty. However, this may result in a starvation for low-priority transactions. Further, the transmission order of different PQs is based on their priorities.

VI. SIMULATION AND RESULTS

We evaluate the performance of TATM scheme. All the algorithms are known to preserve network topology in hybrid wireless networks. In the first simulation, 50 mobile terminals are uniformly distributed in a 1000mX1000 m region. The transmission ranges of nodes are uniformly distributed in [200 m, 250 m]. The adaptive topology management significantly reduces the power requirement of each node, while maintaining network connectivity.

A. Simulation setup

We consider a superstore wireless simulation environment to test the proposed topology management scheme. It consists of a WiFi network, which is used to consolidate all user transactions details and transmit to local server. The mobile customer can be connected to superstore via GSM network. In a superstore, request transactions are generally of few kilobytes, whereas the response transactions have packet sizes of multiple megabytes. Hence it is important to consider the downlink transactions rather than up link transactions.

These characteristics create very challenging demands upon the network, which must accommodate the associated bandwidth and latency effects to downlink transactions. The table III describes the QoS parameters of GSM and WiFi networks.

TABLE III
QOS PARAMETERS OF GSM AND WIFI NETWORKS

Parameters	GSM	WiFi.
Latency	700ms-4s	20-25ms
Jitter	4s	8ms
Packet error rate	1-2%	1-10%
Maximum Available BW	12Kbps	11Mbps

In our simulation, we consider the downlink transactions for the resource estimation and allocation. All customer launched transactions come to the server. At the server resource are estimated for outgoing transactions based on their priority. The downlink resource requirement can be varied in accordance with transaction priority.

The superstore customers are assumed to use various devices for transaction with superstore server such as laptop, HP iPAQ PDA with GSM and WiFi connected mobile phone. The Cisco AP 1200 series gateway is used for the WiFi wireless network. The simulation under consideration uses different transactions with different resource requirements.

Transaction arrivals are assumed to follow independent Poisson processes and the service time of each transaction is considered to be exponentially distributed. This section uses simulation experiments to validate the proposed scheme. The following assumptions are considered in simulation.

- We consider Hybrid Wireless Network(HWN) consisting of two resource access networks: GPRS/GSM and WLAN(e.g., IEEE 802.11b).
- The arrival of new/handoff transaction in a cell forms a Poisson process.
- Mobile hosts are multi-mode.
- GPRS/GSM resources are considered as the main resource constraint.
- The two resource access networks can be owned by the same service provider.
- Each macro-cell area with multi-RAN coverage is served with individual common resource management.
- Each transaction is equivalent to one packet (maximum size of 1500bytes).
- The arrival of new/handoff transaction in a cell forms a Poisson process.

In superstore wireless networks, bandwidth negotiation and renegotiation have to be performed during call setup, vertical handoff (VHO) or handling a change in the network state. Bandwidth or QoS provisioning is the major challenge in end to end QoS support.

The superstore wireless network simulation topology is Shown in Fig.4. We assume that the handover probability from WiFi to GSM and GSM to WiFi is 95%. The system capacities for the WiFi and GSM networks are 11Mbps and 12Kbps respectively.

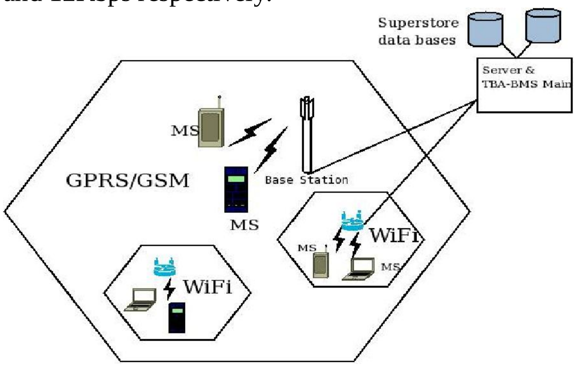

Fig. 4. Simulation environment

For simplicity, we consider 50 different transactions each of which have different resource requirements. The reservation signaling cost before the establishment of new or hand-off connections is set to 0.01% of WiFi capacity. For clarity, all the relevant simulation parameters are given in Table IV.

TABLE IV: Simulation parameters

Parameter	Value	Parameter	Value
WiFi capacity (W)	11Mbps	Session time	EXP 5
GSM Capacity(G)	12Kbps	Guard band	2%
Reservation Signaling	0.01%	Simulation time	10000s

Each simulation was run for ten thousands seconds. In order to estimate the available resource, we consider 400 transactions, few transactions going from GSM to WiFi. Some transactions are initiated in GSM or WiFi networks themselves. Some transactions are initiated in WiFi and going to GSM. Each simulation experiment was run until its stable state.

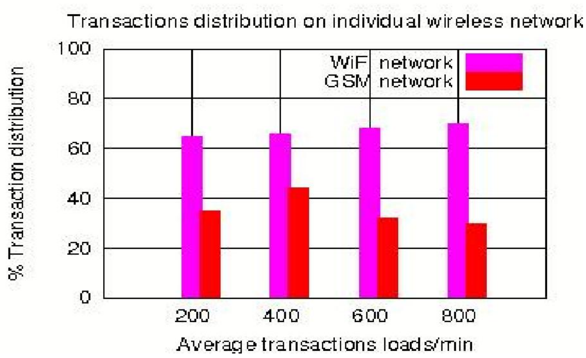

Fig. 5. Average transaction loads VS Loads on individual networks

Fig.5 shows average transaction loads verses loads on the individual networks. From figure, we notice that transaction loads are distributed evenly in both WiFi and GSM networks.

The explanation of the number of transaction versus resource utilization is shown in Fig.6. From the figure we notice that the transaction aware topology management scheme utilizes the available resources efficiently in the superstore at peak time of the business.

Fig. 7 presents the evolution of the rate of transactions/hour in the superstore, sampled every 5 min. The average rate is around 100 transactions/hour and the peak rate 986 transactions. From the figure we see that maximum traffic occurs between 5PM to 9PM in superstore business.

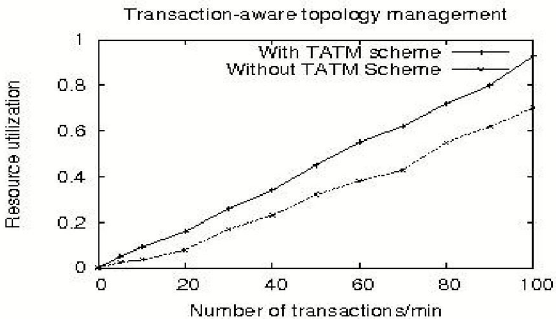

Fig. 6. Number of transactions VS resource utilization tions/hour.

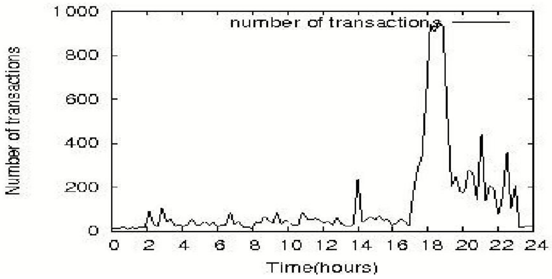

Fig. 7. Time(hours)VS number of transactions

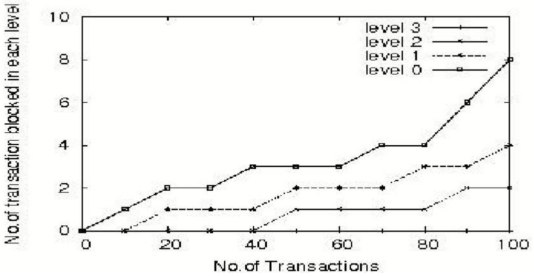

Fig. 8. No. of Transactions VS No. of transaction blocked in each level

The number of transactions versus the number of arriving transactions blocked in each transaction level is shown in Fig. 8. The number of transactions blocked is almost zero in level 3 because our scheme allocates optimum bandwidth to high sensitivity transactions compared to level 1 and level 2. The number of transactions blocked in level 0 is high because of its low TSL.

From Fig. 9, we see that bandwidth utilization increases as transaction rate increases. The proposed scheme allows the network to intelligently allocate bandwidth of each admitted transaction by scheduling the transaction according to transaction priority and gives maximum bandwidth for high priority transactions.

The transaction arrival rate versus percentage of link utilization is given in the Fig. 10. From the figure, we notice that link utilization increases as transaction rate increases. The proposed scheme allows the network to intelligently allocate resources of each admitted transaction by scheduling the transaction according to transaction priority and gives resources bandwidth for high priority transactions.

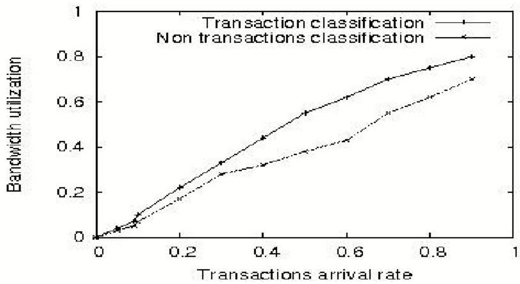

Fig. 9. No. of Transaction VS bandwidth utilization at hybrid wireless network

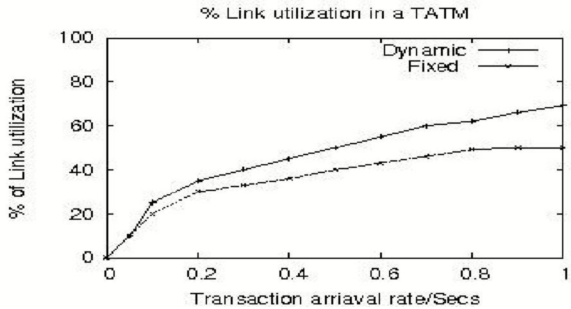

Fig. 10. Transaction arrival rate/Secs VS Link utilization at hybrid wireless network

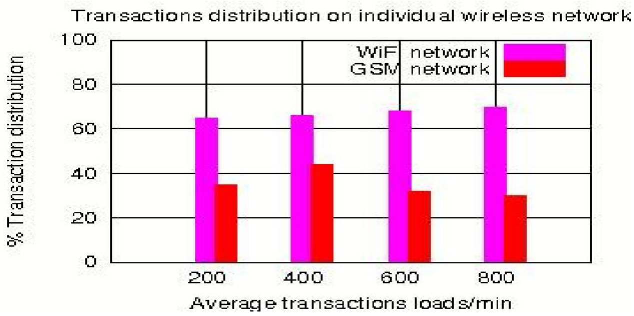

Fig. 11. Average Transactions load/Min VS Percentage of transaction distribution on individual wireless network.

Fig.11 describes the number of transaction verses traffic distribution on individual networks. From the figure, we notice that more number transaction will be supported by the WiFi network when compare to GSM. GSM will support high mobility with less data rate.

VII. CONCLUSION

In this paper, we have proposed an adaptive algorithm to maintain topology of hybrid wireless superstore environment with transaction and individual load detection method. The adaptations include to choose the best network connection for the response, and to perform network connection switching when network situation changes.

We have proposed the topology management scheme aiming to select the best network among available wireless networks and to maximize the resource utilization in hybrid wireless networks. It works on the basis of allocating a fixed amount of resource for transaction response based on transaction sensitivity. To gain more resource to admit those prioritized transactions, the system can consider the downlink transactions rather than uplink transactions. Our simulation has shown that the new scheme has outperformed the original topology management and it is simpler than the original rate borrowing scheme.

REFERENCES

[1] J.Kilpi, A portrait of a GPRS/GSM session, Proceedings of ITC oc, Berlin Germany, 2003.

[2] A.K. Salkintzis, C Fors, R. Pazhyannur, WLAN-GPRS integration for next-generation mobile data networks,IEEE Wireless Communications 112-124 9(5)(2002).

[3] P.S. Henry and H. Luo, WiFi: Whats Next? IEEE Comm. Magazine, vol. 40, no. 12, pp. 66-72, Dec. 2002.

[4] P. Serrano-Alvarado, C. Roncancio, and M. Adiba, A Survey of Mobile Transactions, Distributed and Parallel Databases, vol. 16, no. 2, pp. 193- 230, 2004.

[5] M. Stemm, R.H. Katz, Vertical handoffs in wireless overlay networks, ACM Mobile Networks and Applications (MONET) 335-350,3 (4) (1998).

[6] N. Montavont, T. Noel, M. Kassi-Lahlou, MIPv6 for multiple interfaces, IETF Internet draft, draft-montavontmobileip-mmi-00.txt, July 2002.

[7] R. Ramanathan and R. Rosales-Hain, Topology control of multihop wireless networks using transmit power adjustment, in Proc. IEEE INFOCOM, vol. 2, Tel Aviv, Israel, pp. 404413, Mar. 2000.

[8] S. A. Borbash and E. H. Jennings, Distributed topology control algorithm for multihop wireless networks, in Proc. Int. Joint Conf. Neural Networks (IJCNN 02), Honolulu, HI, pp. 355360, May 2002.

[9] V. Rodoplu and T. H. Meng, Minimum energy mobile wireless networks, IEEE J. Sel. Areas Commun., vol. 17, no. 8, pp. 13331344, Aug. 1999.

[10] D. Rosenthal and F. Fung, gA Test for Non-disclosure in security level translations, h in The IEEE Symposium on Security and Privacy, pp. 196- 206, 1999.

[11] S. Sutikno and A. Surya, gAn architecture of F(22N) multiplier for elliptic curves cryptosystem, h in The ISCAS 2000 on Circuits and Systems, vol. 1, pp. 196-206, 2000.

[12] R. Wattenhofer and A. Zollinger, XTC: A practical topology control algorithm for ad-hoc networks, in Proc. 18th Int. Parallel and Distributed Processing Symp. (IPDPS04), Santa Fe, New Mexico, pp.216223, Apr. 2004.

[13] P.Gupta and P. R. Kumar, The capacity of wireless networks, IEEE Trans. Inf. Theory, vol. 46, no. 2, pp. 388404, Mar. 2000.

[14] N. Li, J. C. Hou, and L. Sha, Design and analysis of an MSTbased topology control algorithm, in Proc. IEEE INFOCOM, vol. 3, San Francisco, CA, pp. 17021712, Apr. 2003.

[15] Sun J, Riekki J, Jurmu M and Sauvola J, Adaptive connectivity management middleware for heterogeneous wireless networks. IEEE Wireless Communications, 12(6), 2005:18-25

Pallapa Venkataram received his Ph.D degree in Information Sciences from the University of Sheffield, U.K. in 1986. He is currently a Professor of Electrical Communication Engineering with Indian Institute of Science, Bangalore, India. Prof. Pallapa's research interest includes protocol engineering, wireless networks, network management, computational intelligence applications in communication, mobile computing security, and multimedia systems. He is a Fellow of IEE (England), Fellow of IETE (India), and a Senior member of IEEE Computer Society. Dr. Pallapa is the holder of a distinguished visitor diploma from the Orrego University, Trujillo, Peru. He has authored more than three books, and published over 250 papers in International/national Journals/conferences.

Shankaraiah received his B.E. degree in Electronics and Communication Engineering from Mysore University, Mysore, India, in 1994, M.Tech. Degree in Digital Electronics and Communication Systems from Mysore University in 1997. He has more than 10 years of teaching experience in engineering. From 2007 he is a research scholar in PET unit, department of Electrical Communication Engineering in Indian Institute of Science, Bangalore, India. His research interest includes bandwidth management, Quality of Service (QoS) management, topology management, and Energy management for hybrid wireless superstore environments. He is a student member of IEEE and life member of India Society for Technical Education (LMISTE).