# ATM based WMN Architecture for Distributed Generation Systems in Electrical Networks

S. V. Vambase
Research Scholar[$] and Assistant Professor[*],
[$]VTU, Jnana Sangama, Belagavi,
[*]Dept. of M. Sc.(Computer Science),
BLDEA's S.B.A & KCP Science college,
Vijayapur, Karnataka, INDIA.
santosh.vambase@gmail.com

S. R. Mangalwede
Professor,
Dept. of Computer Science & Engineering,
Gogte Institute of Technology,
Belagavi, Karnataka, INDIA.
srmangalwede@gmail.com

***Abstract*— The Asynchronous Transfer Mode (ATM) supports for different traffic characteristics and QoS requirements. The Wireless Mesh Network (WMN) is suitable for interdisciplinary mechanism such as effective sharing of electricity. This paper investigates the ATM for WMN. This article focuses on effective sharing of electricity across the electrical sub-network (including Distributed Generation systems in electrical networks) and proposes a novel addressing scheme, routing protocol, payload structure for ATM based Wireless Mesh Networks. The proposed system builds wireless mesh network based on ATM, used to exchange information (such as current status, predicted status of electricity generators, etc.) between mesh nodes aka. electrical meters (in WMN).**

***Keywords*— *Wireless Mesh Networks; Electrical Networks; Distribution Networks; Wireless ATM; Routing protocol.***

## I. INTRODUCTION

Presently there are a wide range of technologies that support wireless communication. The wireless technology must support two basic functionalities:

(a) Locating the end users and
(b) Re-routing connections when users move.

Thus, to provide mobility, the existing technologies replicate the above mentioned functionalities within their respective network infrastructure.

An important motivation for ATM based Wireless Mesh Networks is to provide a high-speed backbone network that supports these two fundamental primitives, and thereby provide a common infrastructure network to a diverse set of wireless technologies. The figure 1 depicts the topology of ATM based wireless mesh network for electrical networks. Each Mesh Node is connected to neighbor Mesh Node and high speed Mesh Relay. The Mesh Relay works as transceiver between Mesh Router and Mesh Nodes. The Mesh Router is connected to Mesh Server.

The figure 2 represents the architecture of mesh node. The mesh node consists of various modules viz., query processor, fault identification, etc. The energy meter module measures the power consumed/produced at consumer premises/Distributed Generation systems (DGs) respectively. The memory and EEPROM are used to store the data and address respectively. The fault identification module diagnoses the fault. The mesh relay exchanges the information over proposed network.

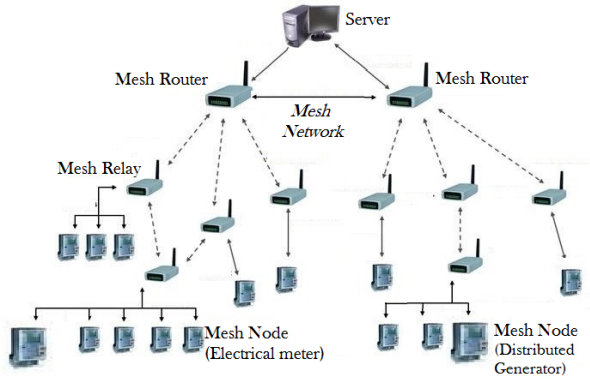


Fig. 1. Proposed ATM based WMN for electrical network.

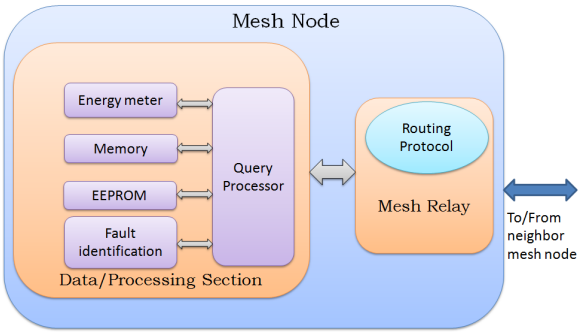


Fig. 2. The architecture of mesh node in proposed system.

This paper extends the work proposed by authors in [1]. The authors focus on Wireless Mesh Network that best suits for electrical networks with DGs and propose a modified addressing

scheme, routing protocol and payload structure over ATM. This article focuses on integration of ATM and WMN to have effective communication among mesh nodes. The mesh nodes represent transmission devices in electrical network.

The remaining paper is organized as follows: Section 2 discusses the network architecture. In section 3, we discuss the payload structure while section 4 discusses the routing mechanism for the proposed system. The interworking of proposed ATM and WMN is explained in section 5 and finally in section 6, we summarize the related work and conclude.

## II. Network Architecture

The proposed system consists of two different networks viz., electrical networks and Wireless Mesh Networks. The electrical devices are equipped with computing and communication capability and each such device is referred to as Mesh Node. Each Mesh Node performs the following functionalities:

a) The Query Processor fetches the required data from energy meter, memory, EEPROM and fault identification,

b) The Query Processor computes the fetched data forms the result for transmission over the network, and

c) The Mesh Relay module acts as transmitter/receiver/relay in the proposed system.

The ATM is basically designed for wired networks. However, ATM for wireless network has to address various issues [2-11]. The authors propose a distinct addressing scheme for wireless ATM. The proposed architecture uses 10 byte address for signaling. The signaling is used at both private and public User-Network Interface (UNI). The figure 3 represents ATM addressing scheme for proposed system.


Fig. 3. The proposed ATM addressing scheme for WMN.

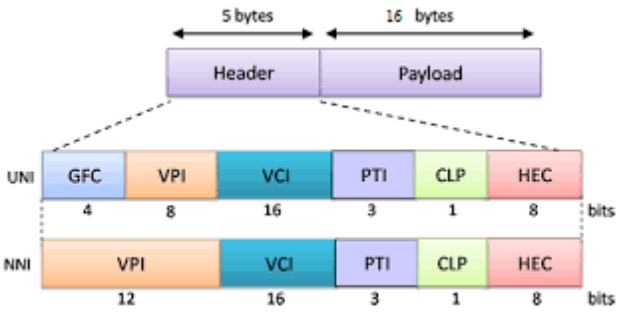


Fig. 4. The ATM cell header structure for WMN.

The addressing scheme in proposed ATM consists of three components:

(a) 4 bytes geographical longitude,
(b) 4 bytes representing geographical latitude and
(c) 2 byte representing the index value.

The mesh node in proposed architecture can be identified by geographical longitude (4 bytes) and geographical latitude (4 bytes). However, index value (2 bytes) is used to identify multiple mesh nodes at same location distinctly.

The ATM cell header in proposed system is similar to the traditional ATM cell. Unlike the traditional ATM cell payload, the proposed ATM cell payload is16-byte long. The header is composed of six elements, each detailed in figure 4. Section 3 discusses the proposed changes in the payload structure in detail. The conventional approach differs with the proposed architecture in following aspects:

a) Exclusion of MAC address usage,

b) Use of Global Positioning System (GPS) / satellite for location identification,

c) Use of Address Discovery Protocol (ADP) to obtain unique address for Mesh Node, and

d) Reduction in address length in ATM addressing scheme.

The mesh node communicates with the GPS during the initialization phase. The mesh node obtains address (10 bytes) using Address Discovery Protocol and stores the obtained address in EEPROM. The obtained address can be used as hardware address for further communication within the wireless mesh network. The proposed addressing scheme has advantages such as ease of routing and reduced overhead traffic. The mesh nodes that perform relay function act as ATM switch.

The mesh nodes in proposed architecture should have routing table that needs to be updated whenever necessary. The architecture uses proactive routing protocol where the routing table contains multiple entries for each neighbor node. Each mesh node in the proposed architecture supports two functions: generating traffic (node) and forwarding the incoming traffic (relay). In the proposed architecture, the mesh nodes consist of radio ports along with the components of proposed ATM network. The radio port of mesh node provides:

(a) Connectivity to any other mesh node via a wireless link and
(b) Cell switching function between one or more of its wireless interfaces.

Compared to an ATM network with wire-line links and fixed mesh nodes, the proposed architecture is different in three ways as detailed below.

### A. Multi-Access Wireless Medium

Wireless media are generally associated with a higher bit error rate and lower bandwidth. A specific physical layer (radio) protocol and data link control (DLC) protocol are needed to transmit ATM cells over wireless links, with reliability and yet maintaining link utilization at an acceptable level.

### B. Location Management

In wireless network, the location of a mesh node may no longer be deduced from its endpoint address. Additional addressing schemes and protocols are needed to locate and track mesh nodes, along with suitable modifications to the connection setup process.

### C. Handoff

In the proposed architecture, the mesh nodes should support mobility. A mesh node in the proposed architecture represents electrical transmission device such as energy meter, DGs, etc. In the proposed network, the Mesh Nodes will be at determined location during the communication. Hence, handoff is not a major issue. On the other-hand, in case, if a mesh node changes its location, it should advertise the change of address to nearest mesh node.

It is envisaged that the proposed architecture will have the following advantages:

• The end-to-end connection path set up is optimal.

• The size of the network routing table remains unaltered due to the number of mesh nodes within the system. Each mesh node advertises reachability to its neighbor nodes.

## III. Payload Structure In The Proposed Approach

In this section, we discuss the structure and components of payload for proposed wireless ATM cell. Unlike conventional ATM cell, the proposed system uses ATM cell with 5-byte header and 16-byte payload. The proposed payload structure is depicted in figure 5. The description of proposed payload[1] is as below:

*1) Existing count (Units):* The value representing total amount of power consumed at the consumer premises (foremost count to existing count).

*2) Time stamp:* The time stamp representing date and time of initiation of query execution.

*3) Current[2] consumed:* The density of electricity (Ampere) consumed by consumer.

*4) Voltage[2] consumed:* The voltage (Volts) at which the electricity is being consumed.

*5) Power[2] consumed:* It is an auto-computed field representing power (Watt-Hour) being consumed at consumer premises.

*6) Power[2] produced at DGs:* It is an auto-computed field representing the power (Watt-Hour) produced at Distributed Generation system.

*7) Reserved:* Field reserved.

*8) Meter capacity (Max.)*: The maximum electricity allowed for consumer or maximum capacity of DGs producing electricity. In DGs, this field indicates maximum power (electricity) that can be produced at DGs.

Table I provides the length of each field in payload structure shown in figure 5. The maximum power consumption in each session[3] is assumed to be less than 65535 units. The time stamp is in standard format viz., UTC. The maximum current and voltage per session assumed to be less than 65535 Amps and 256 Volts respectively. The length of auto-computed field (Power Consumed) is set to 24-bit so as to store product of Voltage Consumed and Current Consumed. The maximum capacity of DGs is assumed to be 4 MW (Mega Watt). The payload of 10 bits is reserved for future use and finally, the capacity of energy meter module is 1MW.

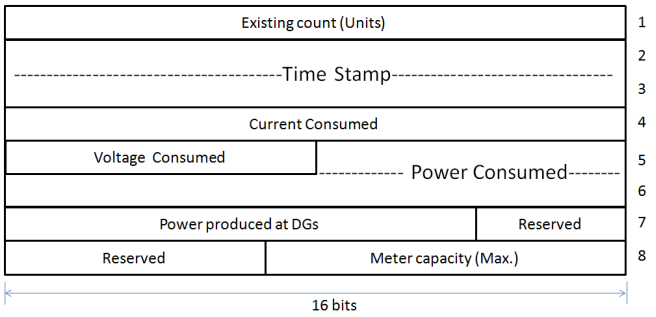


Fig. 5. The payload structure for the proposed system.

TABLE I. Length of each field in the payload structure.

| Field | Length (bits) |
|---|---|
| Existing count (Units) | 16 |
| Time stamp | 32 |
| Current consumed | 16 |
| Voltage consumed | 8 |
| Power consumed | 24 |
| Power produced at DGs | 12 |
| Reserved | 10 |

[1] The fields/terms in proposed payload belongs to electrical network

[2] The *Power* is the unit to measure electricity consumption and is calculated as *Power= (Voltage x Current)*.

[3] The term session refers to the time duration between two consequent billing of electricity.

| | |
|---|---|
| Meter capacity (Max.) | 10 |

## IV. Routing Mechanism

This section focuses on routing mechanism in proposed network. The routing mechanism in conventional ATM networks use IP address and MAC address. The proposed routing mechanism uses 10-byte unique address as hardware address thereby excluding 48-bit the MAC address and IP address. The routing protocol plays vital role in relay module of the mesh node.

In ATM networks, statically built virtual circuits or virtual paths get obsolete causing weak support for re-routing the cells in the event of a failure. The proposed system, dynamically builds Permanent Virtual Paths (soft PVPs) and Permanent Virtual Circuits (soft PVCs), by specifying the characteristics of the circuit and the two end points. Finally, proposed ATM networks can create and remove Switched Virtual Circuits (SVCs) on demand when requested by an end piece of equipment.

### *A. Traffic policing*

When an ATM circuit is set up each switch on the circuit is informed of the traffic class of the connection. To maintain network performance, the proposed network applies traffic policing to virtual circuits to limit them to their traffic contracts at the entry points to the network, i.e. UNIs and NNIs: Usage/Network Parameter Control (UPC and NPC) The proposed network uses non-real-time variant of VBR (Variable Bit-Rate) traffic class and serves for bursty traffic. The network uses Generic Cell Rate Algorithm (GCRA), which is a version of the leaky bucket algorithm. The traffic shaping takes place in the Network Interface Card (NIC) in mesh node, and attempts to ensure that the cell flow on a virtual circuit will meet its traffic contract. Since the network uses GCRA, this algorithm is normally used for traffic shaping as well.

### *B. Virtual Circuit routing*

The proposed ATM networks supporting soft-PVP, soft-PVC, and SVC use the Private Network Node Interface or the Private Network-to-Network Interface (PNNI) protocol. PNNI uses the IS-IS to route IP packets to share topology information between switches and select a route through a network. PNNI also includes a very powerful summarization mechanism to allow construction of very large networks, as well as a Call Admission Control (CAC) algorithm which determines the availability of sufficient bandwidth on a proposed route through a network.

### *C. Call admission and connection establishment*

The proposed network establishes a connection before two parties can send cells to each other. In ATM this is called a Virtual Circuit (VC) that can be a Switched Virtual Circuit (SVC), which is created as needed by the communicating parties. The SVC creation is managed by signaling, in which the requesting party indicates the address of the receiving party, the type of service requested, and traffic parameters applicable to the selected service. Call admission is then performed by the network to confirm that the requested resources are available and that a route exists for the connection.

## V. Interworking Of Proposed ATM And WMN

In this section we discuss the working of proposed ATM in Wireless Mesh Network for Electrical Networks. The proposed ATM makes use of 10 byte address for identifying a node on the network. The cell structure of proposed ATM is similar to the cell structure of ATM with wire-line links and fixed nodes. However, the payload structure is as detailed in Section 3.

During the initialization phase, the mesh node communicates with GPS to obtain Address by using Address Discovery Protocol. The obtained address is 8 bytes in length. The mesh node now sends a Network Join request to the mesh server. The mesh server responds to the request by providing Index Value (2 bytes). The mesh node integrates Address with Index Value and forms a globally Unique Address (10 bytes). The Unique Address is stored in EEPROM of respective mesh node and is used for further activity.

The routing mechanism in the proposed system is elaborated in Section 4 of this paper. The unique feature of mesh nodes in the proposed architecture is that the mesh node during the communication acts as fixed mesh node. However, it can have mobility during idle state (mesh node is turned off). As long as mesh node is active, the mesh node uses obtained address (initialization phase) for communication. To change the location, the mesh node needs to preserve the context and turned off. When the mesh node is restarted, it repeats the initialization phase. The obtained unique address (after restart) is compared with unique address (former) in EEPROM of mesh node. If both the addresses are similar, the mesh node continues functioning. On the other-hand, if dissimilar, the former address in EEPROM is replaced with latter address in mesh node and in its neighbor nodes are updated.

The mesh server in proposed WMN maintains a record showing various information such as mesh node's data (readable information) and unique address (10 bytes). The mesh server receives Network Join (containing 8 byte geographical location identifier) request from various mesh nodes. The mesh server makes fresh entry in the record and assigns an Index Value to it. After making an entry in the record, it responds the Network Join request with Index Value. Although, the Unique Address is logical in nature, the mesh server uses it as hardware address of mesh node permanently (as long as the mesh node does not change its location). For a mesh node that changes its location, the mesh server finds appropriate record and updates the same with new Unique Address.

The other part of proposed architecture is Distributed Generation systems (DGs). The DGs executes prediction

mechanism along with producing the electricity. The prediction mechanism in DGs enables the prior estimation of power usage over electrical sub-network.

## VI. Related Work

The interdisciplinary mechanism for resolving the issues owing to DGs in electrical network was first introduced in 2014. The simulation reveals the fact that the Bluetooth technology [12] and ZigBee [13] are unsuitable for the proposed system. However, the wireless mesh network is better suited for electrical networks. The issue related to DGs is its deployment over existing electrical network without changing the network topology (of electrical network). The authors suggest deploying computational and communication capability in various electrical devices for resolving the issues. The information is used to allow the controlled flow of electricity over electrical sub-network. The studies on computer networks reveal that the integration of ATM [14-16] with Wireless Mesh Network can contribute in resolving the issues related to the promiscuous deployment of DGs in existing electrical networks.

## Conclusion

In this paper, we propose an ATM based WMN protocol architecture for an interdisciplinary mechanism (effective sharing of electrical energy). The proposed approach discusses the suitability of adapted ATM in Wireless Mesh Network for resolving the issues owing to DGs in electrical network. The advantages of adapted addressing scheme for ATM based WMN in connection establishment and overhead traffic control is discussed in this paper. The significance of adapted payload and routing protocol in the proposed system is also discussed in this paper. The future scope includes implementation of the proposed system and verifying the performance by applying it for the electrical distribution networks so as to ascertain the efficacy of the proposed architecture.

## References


[1] S V Vambase, S R Mangalwede, "A Novel Cross Layer Wireless Mesh Network Protocol for Distributed Generation in Electrical Networks", IEEE –2014.

[2] Shafi, M., Ogose, S., Hattori T., "Wireless ATM Networks", IEEE – 2002.

[3] C. B. Akki, S. M. Chadchan, "The Survey of Handoff Issues in Wireless ATM Networks", IJNS – 2008.

[4] Fumin, Xinhua, Zhangxi, Tongsen, "A Novel Topology for the Zonal Network with Wireless Coverage", Communications and Network – 2009.

[5] Barton, M. ; Bellcore, Morristown, NJ, USA ; Hsing, T.R., "Architecture for wireless ATM networks", IEEE – 1995.

[6] Acharya, A., Princeton, Jun Li ; Rajagopalan, B. ; Raychaudhuri, D. "Mobility management in wireless ATM networks", IEEE – 1997.

[7] Patiyoot, D., Shepherd, S.J. "Security issues for wireless ATM networks", IEEE – 1998.

[8] Wen-Tsuen Chen, Nat. Tsing, Wen-Tsung, Shih-Pei, "Traffic management for wireless ATM networks", IEEE – 1998.

[9] Raychaudhuri, D., Princeton, "Wireless ATM networks: technology status and future directions", IEEE – 1999.

[10] Acampora, A., San Diego, "Wireless ATM: a perspective on issues and prospects", IEEE – 1996.

[11] Fan Jiang, Oy, Aanekoski, "Wireless ATM: handover issues", IEEE – 1998.

[12] S V Vambase, S R Mangalwede, "Cooperative Clustering protocol for mobile devices with Bluetooth and Wifi Interfaces in mLearining", IEEE – 2013

[13] Ramanathan Karthikeyan,, "Routing Strategy Selection for Zigbee Mesh Networks", IJCNSS – 2010.

[14] Maolin TANG, "Gateways Placement in Backbone Wireless Mesh Networks", IJCNSS – 2009.

[15] Yun HU, Peng ZHANG, "Parallel-Transmission: A New Usage of Multi-Radio Diversity in Wireless Mesh Network", IJCNSS – 2009.

[16] Jean Louis Ebongue Kedieng Fendji, Jean Michel Nlong, "Rural Wireless Mesh Network: A Design Methodology", IJCNSS – 2015.