W2LAN: Protocol that transforms a 802.11 Mobile Ad-Hoc Network (MANET) into an Ethernet LAN

Francesc Burrull, Francisco Miguel Monzo-Sanchez,
Joan Garcia-Haro, Josemaria Malgosa-Sanahuja

Department of Information Technologies and Communications, Polytechnic University of Cartagena
Campus Muralla de Mar s/n, Cartagena, E-30202, Spain
Ph. +34 968 325365, Fax +34 968 325338
email: {francesc.burrull, francisco.monzo, joang.haro, josem.malgosa}@upct.es

ABSTRACT
To overcome the partial visibility problem that Mobile Ad-Hoc Networks (MANET) exhibit [1] data link-level (level 2 OSI) routing protocols must be considered. Examples of protocols in use are the Ad Hoc On-Demand Distance Vector (AODV) [2] routing protocol -reactive- and the Destination-Sequenced Distance Vector (DSDV) [3] routing protocol -proactive-, and reviews of other routing protocols are available in [4]. A common feature these protocols share is its complexity. Another consideration is that LAN are massively deployed [5] and its protocols and applications are robust and well-known, therefore the idea of keeping them seems reasonable. An Ethernet LAN characteristic is the total visibility issue, that is, a broadcast frame reaches all members of the LAN, however, IEEE 802.11x MANETs do not have it. The proposed W2LAN protocol is a link-level layer protocol that transforms for the higher layers a 802.11x MANET into an Ethernet LAN, maintaining compatibility with other proven and well-established protocols.

KEY WORDS
Mobile Ad Hoc Networks (MANETs), LAN, broadcast protocol, P2P, multimedia, Specification and Description Language (SDL).

1. Introduction

A IEEE 802.11x wireless network with an Access Point (AP) is a collection of nodes that can be observed from higher layers as a conventional Ethernet LAN, except that a radio link to the AP is used instead of wires to a hub/switch. From this perspective, a node out of coverage from the AP is equivalent to a disconnected Ethernet node. In a given moment, a node belongs to the network or does not. The scenario is different when the 802.11 network operates without AP, in an Ad-hoc manner: In this case a typical situation could be, i.e., node A sees node B, that, in addition, sees node C, but A does not see directly C, as depicted in figure 1.

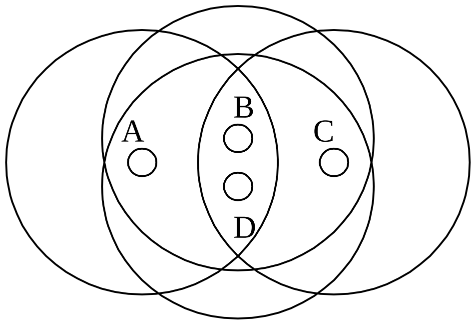

Figure 1: Example of an Ad-hoc 802.11 network topology

The MCDP-LAN protocol [6] exploits the broadcast nature of an Ethernet LAN, but it does not directly apply over an Ad-hoc network, since this previous work assumes a broadcast medium with total visibility (like other Ethernet protocols). An option is to modify MCDP-LAN, but a better one is to design a generic intermediate layer that offers total visibility among nodes, so the unmodified MCDP-LAN is allowed to operate directly on a “LAN”. Note that this “LAN” is, in reality, an Ad-hoc network with an additional layer.

The W2LAN protocol follows a natural model –filtered by evolution- to spread information, emulating a dark room full of people. If someone (Figure 1, A) wants to share a piece of information –information ‘*a*’-, first of all it is announced, “*Does somebody want information ‘a’?”*. People surrounding the source (B and D), if they are interested, they will answer with the request *“Yes, I am interested in information ‘a’”*. Then, if the source gets any requests, it finishes the conversation by delivering information ‘*a*’. The next iteration is performed by the surroundings of the source (B and D), since they have become sources. It should be noticed that the propagation of information *a* is going to be spread to everybody and disappear by lack of interest (nobody will answer C) in a known information.

The rest of the paper is organized as follows: Section 2 illustrates the service provided by W2LAN protocol as well as the assumptions that it is based on. Section 3 describes the vocabulary (messages exchanged) and the encoding (format) of each message. In section 4, the procedure rules of the protocol are discussed. Finally, section 5 explains possible applications of W2LAN and concludes the paper.

2. Service and assumptions

The service that W2LAN protocol offers is to provide total visibility to the nodes that belong to a certain Ad-hoc network. When a node has an Ethernet frame to transmit, instead of transmitting the frame directly, it is passed to the W2LAN layer, witch it will start at this point a new conversation (section 3). Complementarily, when a node has received a complete conversation, its W2LAN layer will deliver the Ethernet frame associated to upper layers as a normal Ethernet device does.

The assumptions of the protocol are two: It operates over wireless Ethernet devices in Ad-hoc mode and whenever it exists at least one possible path between any pair of nodes.

3. Vocabulary and encoding

The W2LAN protocol is based on conversations. A conversation is a triplet {*announce*, *request*, *data*} that carries Ethernet frames among nodes. Each conversation is identified by a 6 byte unique random number, called "conversation ID".

The vocabulary that forms conversations then consists on:

- Announce: The message *announce* is employed when a node has a new Ethernet frame to transmit, either from upper layers or from a just received conversation being retransmitted. It has associated the source MAC address of the node, a conversation ID and the header of the Ethernet frame being spread.
- Request: The message *request* is used the first time that a node receives an *announce* of a new conversation. It has associated the destination MAC address (that is, the source MAC address of the node that sent the corresponding *announce*), the source MAC address of the node and the corresponding conversation ID.
- Data: The message *data* is used if a node that previously had announced a conversation receives any requests for the announced conversation. It has associated the corresponding conversation ID and the data field of the Ethernet frame being spread.

The encoding (format) of each message is depicted in figure 2. It should be noticed that each message fits into an Ethernet frame to keep the protocol simple. The fields of each message are:

- Announce
  Ethernet header fields:
  - Destination address field (6 bytes). In an *announce* frame it is always broadcast (FF FF FF FF FF FF).
  - Source address field (6 bytes). It corresponds to the MAC address of the transmitting node.
  - Data type field (2 bytes). The W2LAN protocol uses for *announce* frames (69 01).

  Ethernet message field:
  - Conversation ID (6 bytes). It is a unique identifier, which is associated with every frame that belongs to a conversation.
  - Ethernet frame destination MAC address (6 bytes). It corresponds to the destination MAC address of the Ethernet frame that is being spread.
  - Ethernet frame source MAC address (6 bytes). It corresponds to the source MAC address of the Ethernet frame that is being spread.
  - Ethernet frame data type field (2 bytes). It corresponds to the Ethernet frame data type field of the Ethernet frame that is being spread.
- Request
  Ethernet header fields:
  - Destination address field (6 bytes). In a *request* frame it corresponds to the MAC address of the node that previously announced the conversation being carried out.
  - Source address field (6 bytes). It corresponds with the MAC address of the transmitting node.
  - Data type field (2 bytes). The W2LAN protocol uses for *request* frames (69 02).

  Ethernet message field:
  - Conversation ID (6 bytes). It is a unique identifier, which is associated with every frame that belongs to a conversation.
- Data
  Ethernet header fields:
  - Destination address field (6 bytes). In a *data* frame it is always broadcast (FF FF FF FF FF FF).
  - Source address field (6 bytes). It corresponds with the MAC address of the transmitting node.
  - Data type field (2 bytes). The W2LAN protocol uses for *data* frames (69 03).

  Ethernet message field:
  - Ethernet frame data field. It corresponds to the Ethernet frame data field of the

Ethernet frame that is being spread, with the same byte size.

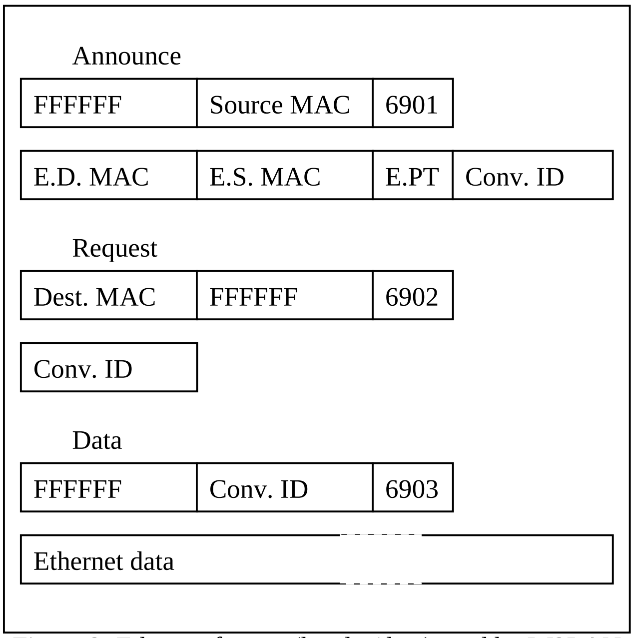

Figure 2: Ethernet frames (header/data) used by W2LAN protocol

4. Procedure rules

In order to prove the correctness of the procedure rules they have been expressed in SDL (Specification and Description Language [7]) , a formal description language accepted as a standard by the ITU (International Telecommunications Union [8]), recommendation Z101-Z104, and to perform an automatic validation of the protocol it has been modelled with the SDL-TTCN Suite from Telelogic [9]. This suite allows the use of MSC (Message Sequence Charts [7]) directly from the validator tool. In the following paragraphs and using text (informal description) the procedure rules are explained.

From the point of view of a node the protocol starts when an Ethernet frame is received from upper layers or a W2LAN frame is received from another node.

In the first case, an *announce* frame is constructed and delivered. Since the Ethernet header has been already transmitted into the *announce* frame there is no need for storage, but the Ethernet data field has to be temporarily stored and identified with the newly created “conversation ID”. The “pending frames list” is used for this purpose. Next, the node should wait a certain time “request timeout”. To allow concurrency of several conversations two additional lists are used, the “timers list” and the “counters list”. An element containing the expiration time of the request window is added to the bottom of the “timers list” every time that the timer is set. An element containing the “conversation ID” and a counter set to zero is added to the bottom of the “counters list”. During the request window period, if a *request* frame is received and the conversation is in the “counter list”, its counter is incremented. When the request window period has expired the pending frame is removed from the “pending frames” list, and if any requests for the frame identified with “conversation ID” have been received, a *data* frame is constructed and sent.

In the case of a W2LAN frame received from other node the “conversations list” is used. This list operates as a circular buffer overwriting the older element. A generic element of this list consists of a “conversation ID”, a Boolean field to mark conversations as pending, and an Ethernet header. The received frame can be an *announce*, a *request* or a *data* message.

If an *announce* frame is received, a check in the “conversations list” is performed, and if the conversation is not in the list a new element marked as pending is added and a *request* frame is constructed and sent.

If a *request* frame is received, a check on the “counter list” is performed, and if the conversation is on the list its counter is incremented.

If a *data* frame is received, a check in the “conversations list” is performed, and if the conversation is in the list and marked as pending, an Ethernet frame is constructed from the header stored in the “conversations list” and the data field contained into the *data* frame received. Next, only if the newly reconstructed Ethernet frame should be received by the node it is sent to upper layers, and in any case a new iteration starts as if an Ethernet frame was received from upper layers.

5. Possible applications of W2LAN and conclusions

An interesting characteristic of W2LAN is that from the point of view of higher layers an Ethernet Ad-hoc network with W2LAN can operate in an equivalent manner than a wireless network with an AP. An immediate application is to provide network coverage to a certain area that, i.e., has suffered a natural disaster, by means of rescue teams carrying mobile wireless devices, with no installations. In this scenario, a LAN can be deployed with no centralized control and with the desired coverage, that is, wherever a node can be deployed it is going to participate in the overall network.

The application of W2LAN has the advantages and drawbacks associated with any decentralized system, and it can be foreseen that it would not scale well in large networks, but a LAN environment should not be large anyway.

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