MCDP-LAN, an efficient Multimedia Content Distribution Protocol over LAN

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ABSTRACT

A very usual architecture is one consisting of a set of POS (Point Of Sales terminal), built on top of PC's, interconnected in a Local Area Network environment. Following the Client-Server model, a POS usually acts as a client, which eventually interacts with the server. This model does not work in the case of a server failure, and, even if the server is robust, the system can be easily collapsed when the number of clients increases and their demands are intense, for example, on the case under consideration in this paper, that is, multimedia traffic. Using the Client-Server model in such scenario leads to deficient service and slow response. Given a platform of a set of POS interconnected with an ethernet hub, the problem is how to distribute multimedia data fast and efficiently. In this paper MCDP-LAN (Multimedia Content Distribution Protocol over LAN), a protocol that solves this problem, is proposed and presented.

1. INTRODUCTION

MCDP-LAN is a broadcast protocol [1] based on two key points. First, due to the broadcast nature of the LAN medium, the communications are going to be implemented as broadcast, addressing directly link layer functions and avoiding increasing protocol burden in other higher communication layers. Second, due to the similarity between POS's, all of them are going to be able to behave in the same way, avoiding the strict and asymmetric Client-Server model. The main function of MCDP-LAN is to distribute contents, which can be produced by any of the POS, to the rest of the POS. In a particular time, one of the POS may have to provide its user with a content previously generated by any of the POS, and the content has to be delivered as soon as possible. This means that a local copy of the content has to be available to all POS, since it is, a priori, unknown which one is going to supply finally the content. The rest of the paper is organized as follows. In section 2, the application scenario, the assumptions about the system, the services offered, the type of messages to be exchanged, their data format and procedure rules are detailed and discussed. In section 3 the core of the MCDP-LAN protocol is explained. Finally section 4 concludes the paper.

2. PROTOCOL COMPONENTS

The application scenario consists of a collection of POS currently working in an aquarium [2] in Barcelona, Spain. The POS are built on top of commercial PC's provided with large hard drive to store multimedia content. They also have a subsystem to identify multimedia products through a barcode reader. The POS are distributed within the building offering multimedia products to the visitors (i.e. printed copies of digital pictures).

2.1 Services offered

The main service that MCDP-LAN offers is a distributed fast access to multimedia content through reliable replication to all the POS. That is, when a user interacts with a POS, in most cases it already has the desired product locally, which is better than having to download the product on demand associated to the corresponding service delay. Having the desired product locally is achieved by replicating content just at the moment that it appears in any of the POS to the rest of them. MCDP-LAN detects on any POS when a new content arrives and ensures its distribution.

The other service provided by MCDP-LAN is multimedia services sharing. This service allows to any POS to access to any multimedia service present on the LAN, increasing the ability of a POS to deliver a content. Sharing services means that if some of the services are down, the rest of them still can be used. Following with the example of printed copies of digital pictures, if the photo printer of certain POS malfunctions, this POS is able to use the same type of printer attached to another POS.

2.2 Assumptions

The main assumption is that in a LAN environment most of the time the communication between POS is going to be error-free. This assumption is based on the robustness of current 100 Mbps LANs and the use of the 32 bit CRC in the Ethernet cards [3]. The error control scheme and the flow control mechanism implemented -section 3.2- are based on this assumption only.

2.3 Messages exchanged

Two different type of messages are exchanged over our MCDP-LAN: Command and Response messages and Data messages. Notice that all the messages are broadcast, achieving that way a better utilization of the LAN, where all underlying communications are already broadcast in nature.

2.3.1. Command and Response messages

The model that follow the Command and Response exchanged messages is based on the observation of a simple real life situation –filtered by evolution-, that is a dark room with people in. How they know who is in there? How they share information? What happens if someone new enters the room? The observation of these questions leads to the set of messages exchanged, always having into consideration the simplest way and lowest implementation complexity to develop our service using highly available technology to reduce cost at minimum.

There are six Command and Response messages. This reduced number of messages supports the requirements of simplicity for the model.

- WhichServicesAreThere

This message is a request to the LAN. It is generated when a POS needs to update its knowledge of the LAN. This message is going to generate responses from the different POS distributed all over the LAN.

- IHaveServicesAndProducts (POS, services, products)

This message is generated every time a POS experiences a change of state. When the message appears on the LAN the rest of the POS update when necessary their internal lists. This message requires some parameters, such as the number of the POS that generates the message, the multimedia services the POS has (indicates processing power) and the products that the POS has to deliver to the user (indicates load).

- DeliverProduct (POS, product)

This message indicates to the POS that receives it to deliver the product specified in the message to the user.

- WhoHasProduct (product)

This message is generated when a POS does not have the product specified in the message and needs it. This message is going to generate responses from the different POS in the LAN.

- IhaveProduct (POS, product)

This message informs to the LAN that the POS that has produced the message has the specified product.

- GiveMeProduct (POS, product)

This message indicates to the receiving POS to start a broadcast of the product specified in the message.

2.3.2. Data messages

There are three data messages exchanged –packet, ack, nack-. The fact of ack and nack messages being broadcast or unicast does not make any difference in LAN usage, since both cases use the same resources, but the message PACKET being broadcast means that it can be distributed by transmitting once, achieving that way a better utilization of the LAN. The model that the messages exchanged follow is based on the observation of another simple real life situation –filtered by evolution-, that is a classroom with students in. The teacher has to be aware of the rhythm of the students (ACK), sometimes a student ask for repetition (NACK), and some of them do not pay attention losing the content. The observation of these questions leads to the set of data messages exchanged, one for broadcasting information and the other two to positive or negative acknowledgement. The data messages are:

- Packet (POS, product, total number of packets, packet number, data)

This message contains the identifier of the POS sender, product name, the total amount of packets that the product has been split into, the packet sequence number and multimedia data or payload.

- Ack (POS, product, packet number)

This message is the positive acknowledgement of the correct reception of a packet by the POS indicated in its field.

- Nack (POS, product, packet number)

This message is the negative acknowledgement of the reception of a packet by the POS indicated in its field.

2.4 Data format

Two different data formats are present in MCDP-LAN:

2.4.1 Command Format

The command format is based on Strings, because the task of debugging results much easier. A command always consists of the word COMMAND followed by a colon.

- COMMAND: <commandname>;

The commandname values are: WhichServicesAreThere, IHaveServicesAndProducts, DeliverProduct, WhoHasProduct, IhaveProduct, GiveMeProduct, Ack and Nack, always followed by a semicolon.

The next fields, that maintain the same structure, are:

- POS: <POS number>;
- NUMPACKET: <packet number>;
- NUMSERVICES: <number of services>;
- NUMPRODUCTS: <number of products>;
- PRODUCT: <product name>;

These fields only appear in those commands that need them. An example could be:

```
COMMAND: IHaveServicesAndProducts; POS: 2; NUMSERVICES: 3; NUMPRODUCTS: 7;
```

This message indicates that the POS 2 has 3 multimedia services available and 7 multimedia products pending.

2.4.2 Data Format

The data format is also based on Strings. There are two different formats, one for packet and another for acknowledgements:

- PACKET: <POS>; PRODUCT: <productname>; TOTALPACKET: <numpaquet>; NUMPACKET: <numpacket>; LENGHT: <datafieldlenght>; DATA: <data>;
- ACK/NACK: <POS>; PRODUCT: <productname>; NUMPACKET: <numpacket>;

An example could be:

```
PACKET: productname; TOTALPACKET: 2048; NUMPACKET: 345; LENGHT: 1024;
```

This message contains the packet 345 of 2048 of the product *productname*, being its data field size 1024 bytes.

Notice that due to the format of data messages concurrent distribution of products is possible, since all the packets carry information of sender and product name, allowing both sender and receiver to discern between different transmissions.

2.5 Procedure rules

The procedure rules are different for the transient and for the stationary period.

2.5.1 Transient Period

When a POS is turned on it tries to "discover" its environment, that is, which services are offered by the other POS (list of Services by POS), and which load have the other POS (list of load by POS). After that the POS publishes its identity, multimedia services and local load, and finally reaches stationary period.

Notice that a POS that has just started may lack some multimedia contents that its neighbors have. These contents, if ever demanded to the POS, will be, in its turn, requested to be broadcast from a neighbor, having in this specific case performance degradation.

An alternative to solve this problem is that the POS requests the available contents on the LAN and downloads the missing ones from a neighbor. Unfortunately, this approach loads the LAN with content that is already present in most of the POS and maybe it is not going to be consumed in that specific POS.

2.5.2 Stationary Period

Eventually a POS reaches stationary period. In that state 4 different events can occur:

- New content arrival to the LAN.
- New content arrival to the POS.
- A product demand (local or from another POS).
- New POS appearance in the LAN.

Under new content arrival to the LAN the POS updates its list of distributed contents and starts a multimedia content reception –subsection 3.1.2-. If the content arrives to the POS, it starts a multimedia content broadcast –subsection 3.1.1-. If the POS has a product demand it checks if the product can be delivered locally. If the product can be delivered locally, it checks if the content is available locally, and if it is not, a multimedia content reception is started. If the product cannot be delivered locally the request is forwarded to a POS that has the necessary services. If an appearance of another POS occurs, the lists of POS (list of services by POS and list of load by POS) are updated accordingly.

3. MULTIMEDIA CONTENT TRANSMISION

The core of MCDP-LAN is how multimedia content is going to be distributed over the LAN, taking advantage of the broadcast nature of the underlying networking support, avoiding the burden of intermediate protocols between application and network data link layer.

3.1 Multimedia Content Distribution

The MCDP-LAN model is based on an environment where each POS is aware that any transmission in the LAN is shared, therefore different POS will try to minimize their impact on the shared resource LAN.

When a multimedia content distribution takes place all the POS that are in the LAN will be involved. One of the POS will broadcast multimedia content and the rest of the POS will receive it.

3.1.1 Broadcast

The broadcast algorithm of MCDP-LAN protocol starts by dividing the content into consecutive numbered packets. Although fixed and variable packet length is supported, fixed length packets are used for all the packets except the first. When the first packet is transmitted a new list of POS receivers is created empty. When the timeout expires (first packet), the different acknowledgements received (POS receivers), including itself, are added to the list and the second packet is transmitted. When all of the acknowledgement packets contained in the list of POS receivers are received the third packet is transmitted, and so on. Notice that the lists are being used for adapting the rhythm of the broadcast process to the rhythm of the receiver processes.

A special case occurs when acknowledgements are missed. In this case the broadcast of the third packet continues, after the timeout expires, eliminating from the list of POS receivers those receivers that did not acknowledge the preceding packet.

Another special case is when new acknowledgements appear. In this situation the new receivers are added to the list of POS receivers, and their ack will be expected in the next packet transmission.

The last special case is the reception of negative acknowledgements. In this case the list of receivers is cleared, the POS that sent the negative acknowledgement is added to the list, and the broadcast continues from the packet number that was incorrectly received (requested by the nack).

Summarizing, the broadcast algorithm of MCDP-LAN protocol learns which POS are receiving information, updating accordingly the list of POS receivers.

An (incomplete) SDL (Specification and Description Language) [4] block diagram is shown in figure 1.

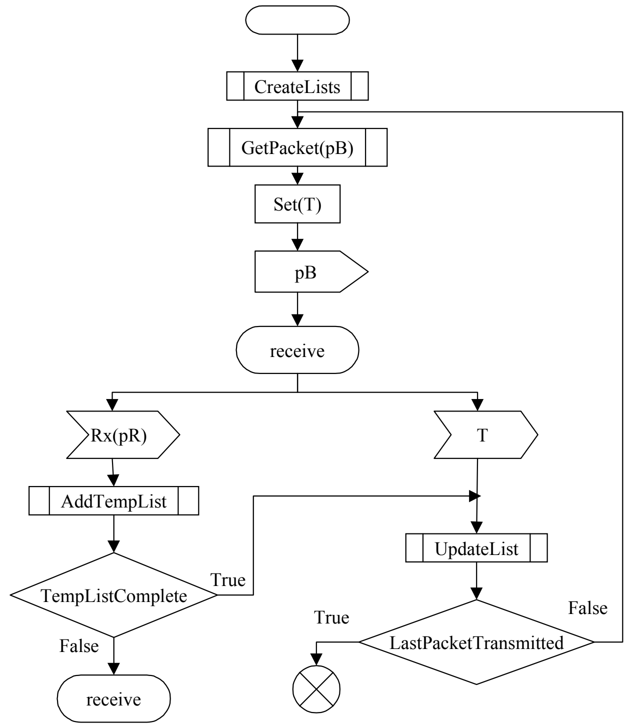

Figure 1: Broadcast Block Diagram

3.1.2 Reception

Reception of multimedia content mainly consists of sending a positive acknowledgement when a packet has been correctly received and it was expected.

A special case is the reception of a packet with unexpected sequence number. This case is solved by discarding that packet and by sending negative acknowledgement of the expected packet.

If during the transmission of a multimedia content a receiver is sending negative acknowledgement packets often, and therefore, affecting negatively to other POS, it automatically aborts the reception of this multimedia content, favouring the normal content reception to the rest of the POS.

An (incomplete) SDL block diagram is depicted in figure 2.

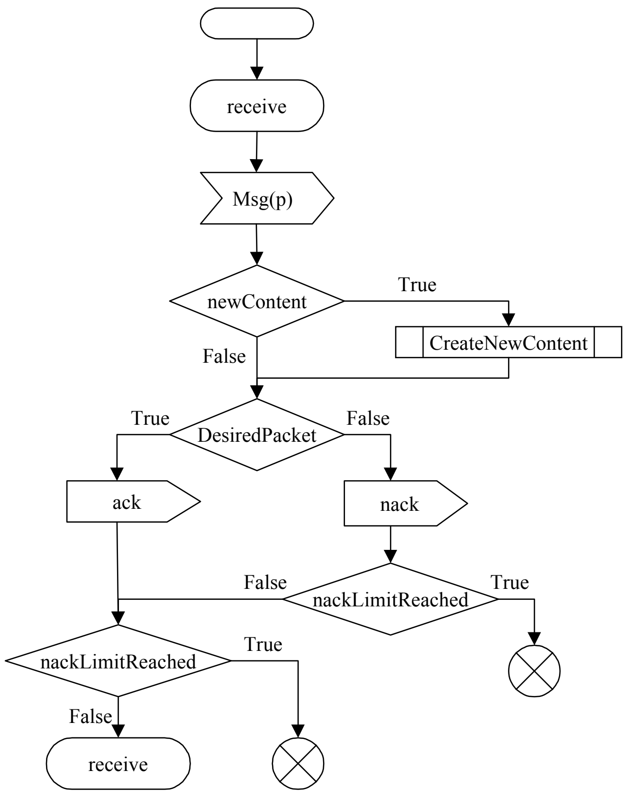

Figure 2: Reception Block Diagram

3.2 Error Control and Flow Control

MCDP-LAN does not have an error control scheme due to the assumptions made by the protocol, and relies on the flow control mechanism for the recovery of lost packets.

MCDP-LAN flow control has some similarities to the well-known Stop and Wait algorithm [5], but modified [6] to consider the broadcast quality of the LAN transmissions. The transmitter only sends a new packet when all the receivers have acknowledged it or a timeout expires. It only repeats (broadcast) a packet when explicitly has been requested through a negative acknowledgement packet. Notice that the MCDP-LAN control mechanism forces the sender to adapt to the rhythm of the receivers.

4. CONCLUSIONS

The main conclusions about MCDP-LAN are:

- Using MCDP-LAN for content distribution instead of the traditional Client-Server model decreases the amount of traffic in the LAN, due to the broadcast nature of the protocol and the fact that a content can be distributed to all the POS using one transmission, that is the minimum possible.
- Using MCDP-LAN, if no POS malfunctions occur the amount of traffic in the LAN is independent of the product demand and independent of the number of POS. The traffic only depends on the rhythm of appearance of new contents in the LAN.

5. REFERENCES

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