OPTIMIZING THE DATA TRANSMISSION USING POINT TO MULTIPOINT NETWORK IN RADIO COMMUNICATION

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Abstract: - Minimizing the cost to transfer large data in radio communication by using point to multipoint network as Central Primary and Secondary stations, which is very useful in remote areas. It can be implemented as one primary station to many Secondary stations: It is the simplest solution, but active area of Primacy Station must cover whole area where the Secondary Stations are placed.

The Secondary Stations can be simple because all of them can communicate at one frequency. The communication between Primary Station and the Control Unit will be simple as well and it can be either wired or wireless. To cover whole area it is necessary to transmit with relatively high power for both Primary Station and Secondary Station to enable low error rate. Also the transmission speed will be smaller due to greater distances. The other disadvantage of this solution is the danger that the Primary Station can be broken and therefore no possibility of the data delivery to any Secondary Station. Because of a single Primary Station, it is not necessary to have logical addressing for the Primary Station at the side of the network between the Central Unit and the Primary Station. The other advantage of this solution is simpler communication software in the Central Unit.

Key-Words: - PS Primary Station, SS Secondary Station, CU Central Unit

1 Introduction

In the last few years we are witness of massive employment of radio communication systems. The radio networks bring many advantages when compared with other solutions such as terminal (user) mobility, cabling system absence in the access network, fast network installation and higher working productivity.

The systems which use the communication channels as the radio links are usually divided into several groups: fixed wireless access networks, wireless communication networks, mobile communication networks and satellite networks

The first radio communication systems were designed primarily for speech or generally for the sound transmission. At present it is evident shift towards the general data transmission. Larger and larger portion of the traffic in radio networks is general data transmission.

But many applications exist, which do not require the global access but only the local coverage. There were several standards developed, e.g. Bluetooth, DECT (Digital Enhanced Cordless Telecommunication), HomeRF, PWT , various types of WLANs and other solution but they are not suitable for some applications due to following reasons:

- they are too complex and expensive,
- the coverage area is too small,
- they don’t allow the broadcast transmission,

Therefore the researchers are forced to design their own solution in many cases. So that there are many proprietary solutions around world but they are not accessible for the others.

The aim of this research work is to design the structure of the network, which enables quite large data transmission between one central unit and many movable slave stations (point to multipoint network) and to work out the part of this solution in detail – the communication protocol for the data link layer.

2 Aim of the work

As it has been described in the Introduction chapter, several standards for local wireless communication networks have been developed. The task, which I wanted to solve, is how to transfer quite large volume of data (up to ones MB) from the centre to the quite big number of the movable stations (up to several hundred or ones thousands). The usage of some of standards specified in the Introduction is not possible and some is possible, e.g. wireless LAN, but the expenses are the main disadvantage of such solution. The price of one IEEE 802.11b PCMCIA or PCI card is approximately $100 and the price of one AP (access point) unit is about $500. When we suppose that we have 200 stations and 5 AP units, we will get the expenses $22,500. In addition to this it is necessary to have apparatuses with the PCMCIA or PCI interface, i.e. computer or similar equipment to which the cards can be connected. The price of each unit can be at least $300, so that additional $60,000 is necessary. Other expenses are necessary. Such solution also requires the switch and the cabling system to interconnect the central unit and the access point units (APs). If we want to use 100 Mb/s ETHERNET and 200 meters distance between the central unit and the AP is not sufficient, it is necessary to use either additional units that recover the signal and prolong the maximum distance (additional switches) or to use the optical fibre (multimode fibre – 100 BASE-FX specification) that enables us to reach bigger distances (approximately 400 m for half duplex and 2000 m for full duplex communication). But the price of the 8-port 100 BASE-FX/ 2-port 10/100 Base-TX switch is approximately $5,000. Let's suppose that multimode two-fibre cables will be used and that the overall length will be 1.5 km. Its price could be $1,500. The overall expenses on this solution can reach almost $90,000.

Because such solution is too expensive I have decided to design new one. The main goal of my work is to design suitable network structure and to work out appropriate communication protocol (frame and message structures, behaviour of the terminal and intermediate stations). It is necessary to consider many aspects:

- locations of the central unit and the slave stations,
- number of the slave stations,
- number of the areas where the secondary stations can receive the data,
- size and the shape of area where the transmission will take place,
- error rate of the radio links,
- maximum transfer speed,
- maximum size of the data unit,
- way of retransmission,

sizes of timers,
the network with one intermediate unit , called the Primary Station (PS) – between the central station (central unit - CU) and the group of slave stations (secondary stations – SSs) one auxiliary unit (primary station – PS) was placed, which divides the communication environment into two parts, CU-PS and PS-SSs. Each part can have different topology and different set of communication protocols.

3 Communication Protocol Design and discussion

3.1 Network structure design

The communication network and protocols that are being designed in this work are primary designed for the transmission of quite large volume of data (up to ones of MB of data) between central unit and many stations (tens or even hundreds) that can be placed in movable equipment. But during the communication the stations are in fixed position. Due to the station mobility the communication channel must be placed into radio environment. The simplest network structure is shown in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**1.

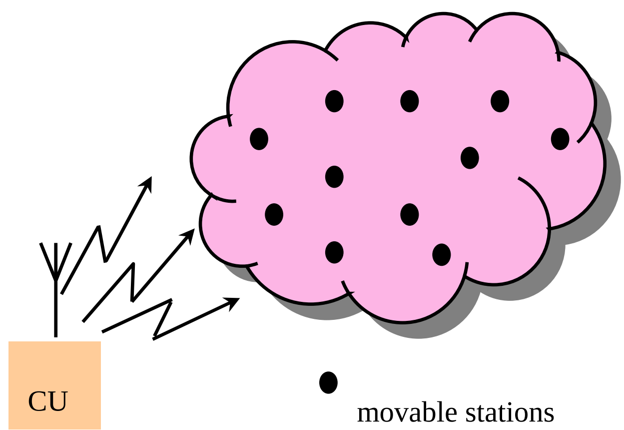

Fig.1: The first view on the network solution

3.1 CU- Central Unit

The radio environment is not the free space and it can be quite complex. Central unit (CU – computer with special software) also can be placed in the office which can be quite far from the area where movable stations stay. So that the network solution will be more complicated than it is shown in previous figure. Let us add another station, which will be placed on the path between central unit and movable stations. Let us call it Primary station (PS) and movable stations Secondary stations (SS). By doing this the network environment was separated into two parts, which can be solved independently. The environment between primary stations and movable stations must stay wireless but the second part of the network can be designed either as wired or as wireless solution and if suitable protocol set is used, for example TCP/IP protocol set, the network environment between CU and PS becomes unlimited. It can consist of one network (wired or wireless, local – for example Ethernet LAN, or global – analogy telephone network, ISDN, GSM), or of group of various interconnected networks (internet). Possible structure of the next design of the network is shown in Fig 15.

3.2 PS – Primary Station

The number of movable stations can be quite big, the area where the movable stations stay can be quite extensive and the environment can be complex, it means that all movable stations may not be accessible from one place (one primary station). This problem can be solved by several primary stations that have suitable position to cover the whole area.

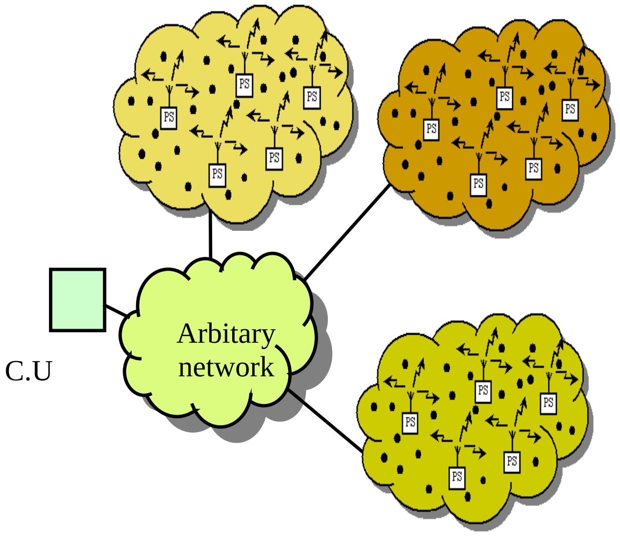

Fig.2: Generalized network solution

This design can be further generalized; it means that there can be several locations within the certain area (e.g. city) where the movable stations usually stay and one control centre (central unit). This situation is illustrated in Fig.2.

The protocol set design consists of the solution of several problems:

- type of communication,
- addressing,
- communication phases,
- frames and messages – structure, maximum length, error protection, error recovery mechanisms.

3.3 Addressing

Physical (unicast) address, socket (multicast) addresses, temporary unicast addresses

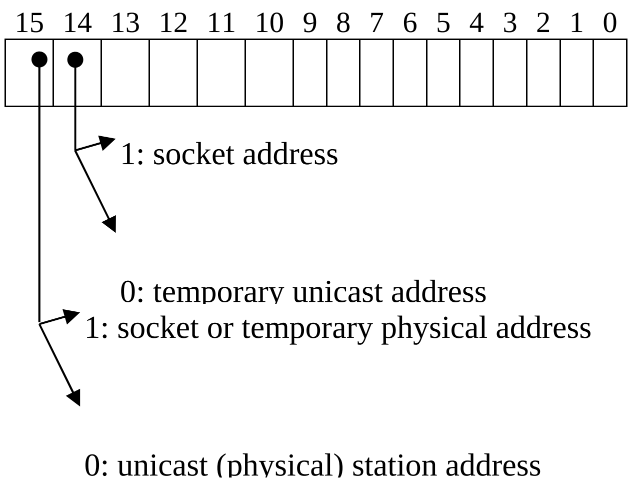

Fig.3: Addressing

All zeros or ones in the rest of addressing field cannot be used to specify certain station or certain socket. Such combinations have special meaning:

Address assignment can be solved by two different ways:

manual assignment

automatic assignment

Address assignment controlled by secondary stations

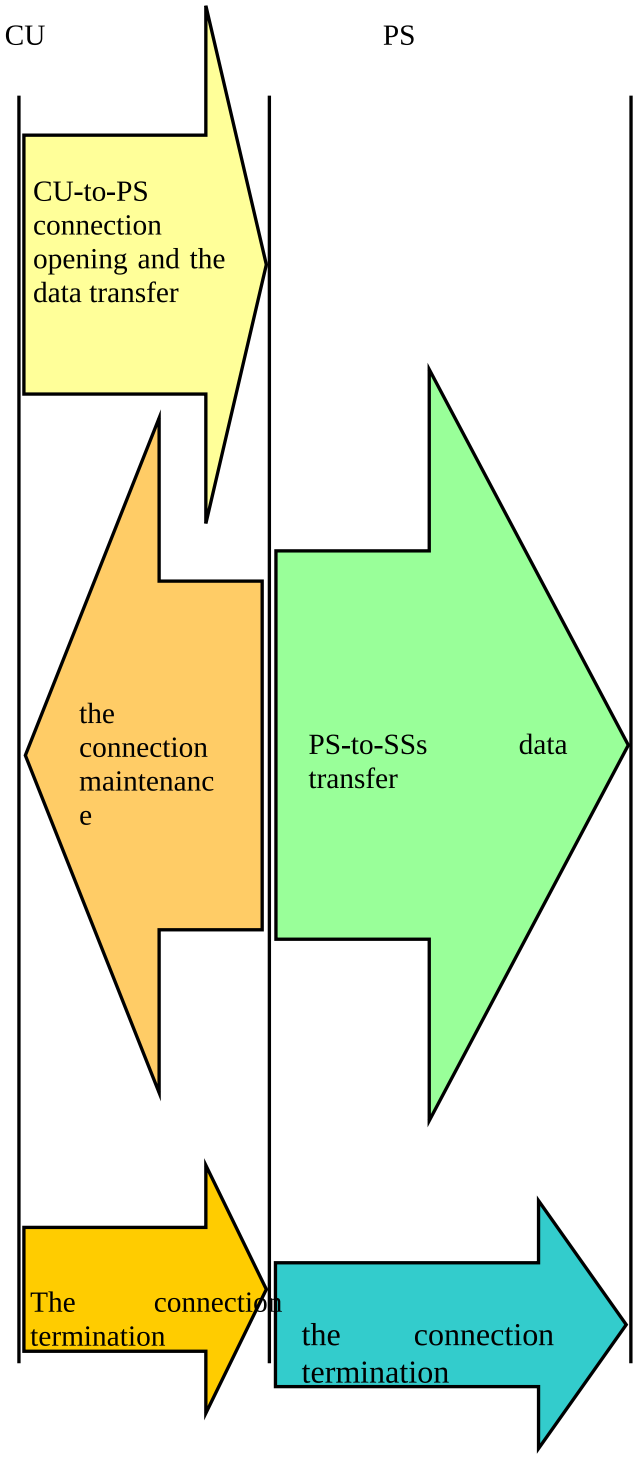

Fig.4: Main parts of communication system with the CU, one PS and many SSs

3.4 Data communication between one primary station and many secondary stations

The communication between primary station and secondary stations consists of several phases, see Fig .5.

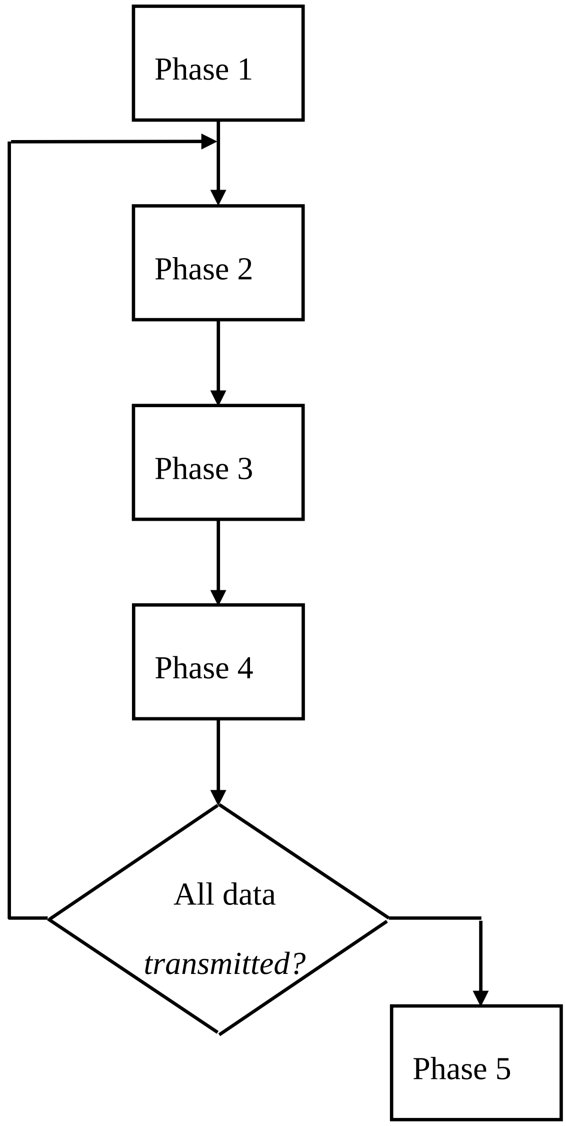

Fig. 5: Communication phase diagram

3.4.1 Phase 1

Session Opening – Opening of the communication circuit between primary station and specified secondary stations. It is verified if all secondary stations presented in the list can communicate with the primary station. If the number of addresses in the list received from central unit is bigger than twenty the opening procedure must be repeated several times for partial groups

3.4.2 Phase 2

Massive Data Transmission – primary station transmits data to secondary stations in blocks of certain size.

3.4.3 Phase 3

Data Confirmation – secondary stations are asked by primary station to send results of data reception, i.e. to confirm the data or to ask for retransmission of data units received with errors

3.4.4 Phase 4

Data Retransmission – the primary station retransmits all data units that were received with errors by any secondary station

3.4.5 Phase 5

End of Communication – the communication is terminated and the socket (analogy of a multicast address in the Internet). The results of communication are evaluated and sent to the central unit CU.

Because the data is transmitted in blocks it is necessary to repeat the phases 2, 3 and 4 till the last data block is transmitted and corrected.

3.5 Data transmission among several Primary stations and many Secondary stations

In the previous chapter the method how to transfer data from the central unit CU to many SSs via one PS has been described. As it has been already mentioned, in many cases the area, which should be covered by the signal, is quite complex or too large so that it cannot be covered by one PS. The solution is to use more PSs.

But many new problems appear and they must be solved. For example some SSs can be reachable from several PSs. What PS is the best for communication and what equipment will decide it? Will it do PS, SS or CU? Is it possible that all PSs can transmit data at the same time? When sequential approach will be selected, does the order of PSs, what they will communicate with SSs according to, have an influence on the overall time that is necessary for data transfer? And many other questions.

Complete designed network consists of two parts:

- communication environment between the Central unit (CU) and group of PSs
- communication environment between the group of PSs and many SSs

3.5.1 Communication environment design between CU and PSs

Several solutions of communication network between the CU and several primary stations (PSs) were considered:

all primary stations have the same importance and there are several possibilities of communication environment:

3.5.1.1 local connection

If the local connections will be used (point-to point link or single LAN, e.g. the Ethernet) and new protocol set will be designed it is not necessary to implement functions of network layer, because the addressing is provided by the data link layer. Two solution were considered:

3.5.1.2 Cabled solution:

1.Ethernet (or another type of LAN) with appropriate protocol set, either a new one or the standard set of protocols – e.g. TCP/IP, see Fig8.

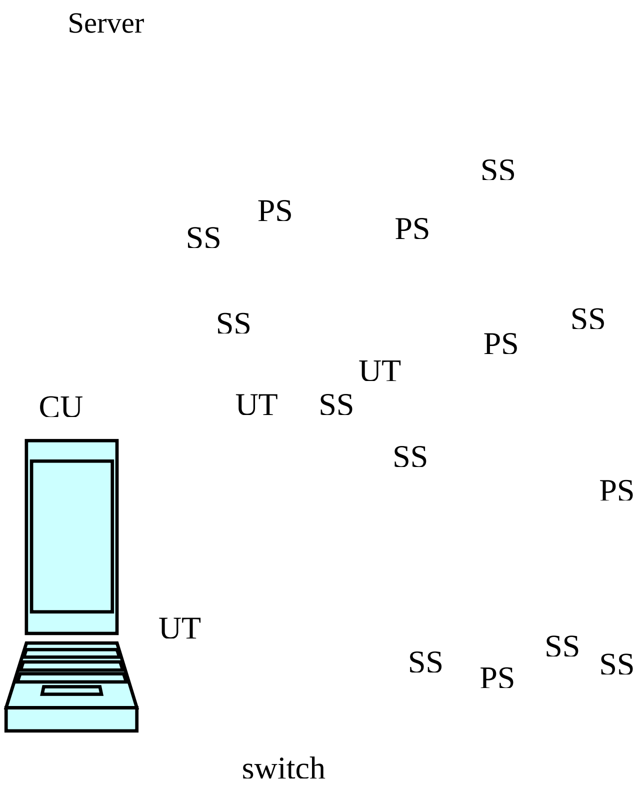

Fig.6: The Ethernet network topology between the CU and The PSs

2. star topology with serial connections to each PS – certain physical layer (two or four-wire lines with appropriate encoding technique, standardized or a new one – RS-422, ASK, FSK, PSK, …) and data link layer (e.g. HDLC – High Definition Link Control protocol) protocols can be selected.

3.5.1.3 Wireless solution

Ad-hoc WLAN (wireless LAN) – peer-to-peer isolated (closed) wireless LAN using a suitable standard (e.g. IEEE 802.11b).

4 Conclusion

The research paper dealt with design of the new network structure that enables quite large volume of data transmission from one centre to many slave stations (up to hundreds). The task was to find a simple, cheap but reliable solution. Existing universal solutions like wireless LANs or Bluetooth are either quite complex ones or do not satisfy all requests for required network type, so that they were rejected.

To solve the communication between the primary and many secondary stations at first the addressing had to be solved. This problem was solved in such a way that the addressing space enables four types of addressing:

- unicast,
- multicast (socket),
- broadcast,
- temporary unicast.

The first type is for the point-to-point communication, the second one for communication between particular primary station and a group of secondary stations, the third type was used for communication between one primary station and all available secondary station. The fourth address type is optional one that can be used for automatic address assignment to the new or recovered secondary stations that have no address assigned. The address length was chosen 16 bits. The first one or two bits specify the type of addressing.

Because the radio environment is not very friendly for data transmission, it is noisy, and a bit overcrowded, the channel with transfer speed 64 kb/s was chosen. Because of relatively high bit error rate the data units cannot be long due to high probability of errors in them and due to frequent retransmissions. This would substantially decrease the throughput of the channel. Therefore 64B value was selected as a maximum data unit length. But the data unit length restriction has brought other problems.

- How to communicate with large amount of secondary stations?
- How to transfer large amount of data?

4.1 Summary of proposed solutions

4.1.1 One primary station to many Secondary stations:

It is the simplest solution, but active area of PS it must cover whole area where the SSs are placed.

The SSs can be simple because all of them can communicate at one frequency. The communication between PS and the CU will be simple as well and it can be either wired or wireless. To cover whole area it is necessary to transmit with relatively high power for both PS and SS to enable low error rate. Also the transmission speed will be smaller due to greater distances. The other disadvantage of this solution is the danger that the PS can be broken and therefore no possibility of the data delivery to any SS. Because of a single PS it is no necessary to have logical addressing for the PS at the side of the network between the CU and the PS. The other advantage of this solution is simpler communication software in the CU.

4.1.2 Many PSs and many SSs

Advantages:

a) Smaller transmission power
b) The higher transmission speed
c) Higher reliability
d) Higher probability of data delivery
e) Possibility of the selection of the PS with the best signal quality by the SSs or the CU

Disadvantages:

a) More complicated software in CU and communication network between CU and PSs
b) More expensive solution
c) More complicated SSs in some cases (when the SSs selects the best PS themselves)
d) More complicated and expensive maintenance

Sequential transmission between many PSs and many SSs

The advantage of this method is:

- Simplicity of the solution (only one carrier frequency)

Disadvantage:

- Slower data transmission

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