Survival of Communications in Ad hoc and M2M Networks: Study of the Applications of Hybrid Intelligent Nodes that Process Simultaneous Signals IEEE802.11h/Bluetooth in Comparison with IEEE 802.11h/802.15.3

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Abstract— **A theoretical comparison of the advantages and benefits of both architectures based on hybrid nodes will be made (interfaces able to communicate simultaneously in different transmission technologies); possible practical applications will be established for specific cases as selection approach (Inter. - vehicule comunications, Smart objets, wireless sensor network, M2M, etc); the necessity to establish the platforms of hybrid nodes in order to assure the coexistence and survival of the communications among these devices will be thought.**

Index Terms— **hybrid nodes , Ad Hoc, M2M, coexistence, survival, IEEE 802.11x, WIFI, Bluetooth, Ultra-Wideband, UWB,WPAN.**

I. Introduction

to think about the coexistence in a single net of nodes that may use different technologies is not new; it has rather become a practical necessity to assure the survival of the communications, as well as the discovery of services and compartment of resources in strange nets where the node mobil moves along; but it is now, when the big manufacturers of the sector have put in the market chips able to transmit in different technologies (Bluetooth and IEEE 802.11b for example) minimizing the interference problems considerably; however, there is a point where some important studies are being studied right now and are those related to the collaboration among these nets. If we take into account that these hybrid nodes could well use software based on artificial intelligence (Microprocessors every time smaller but with bigger capacity of calculus) that facilitates and manages all these aspects, in order to improve even more the field of the same ones.

Now, it is the development of new standards as the IEEE 802.11h which tries to overcome the obstacles of the interferences in the already saturated free band of the 2.4 Gigahertz, and the emerging technology of Ultra-Wideband (UWB, the 802.15.3 PAN standard) with, it will provide a home wireless multimedia network that supports multiple devices without interference with other UWB networks of the neighbors; we will find ourselves with big possibilities of developing new services and applications in the field of the ad hoc computing which will take advantage of these capacities of collaboration and coexistence among these nets[1].

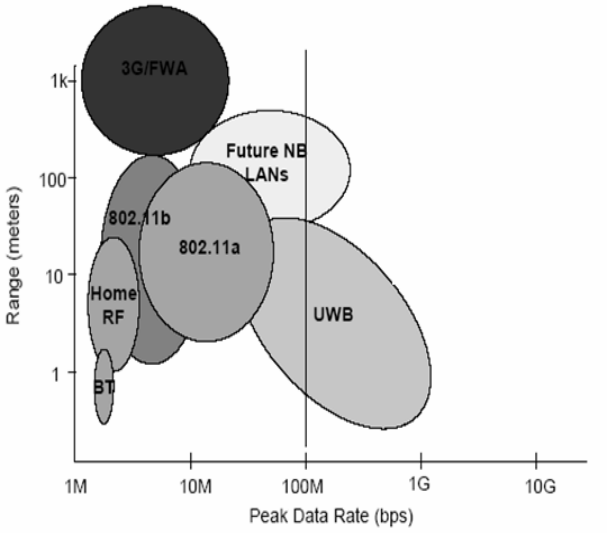

Fig. 1. Review PAN/LAN Standards. Wireless solutions are currently confined to < 100Mbps.

II. New challenges of the nets Ad hoc

The concept of an ad hoc network refers specifically to its capacity for to find fixed networks infrastructures and "to find" a way of communications that allows be connected to it, and to be able to use its services; becoming at the same time, a node of that new network.

The communication among mobile nodes has been topic of

[1] Ultra-wideband Technology for Short-Range, High-Rate Wireless Communications Jeff Foerster Intel Labs.

wide investigation in the field of the Ad hoc nets; especially the related to information routier (DSR, AODV, Swarm Intelligence, Zone Router, etc, all of them for the standards of the IEEE 802.11) and to guarantee a minimum quality of service for the communications that support these flows of information [1].

To compare these protocols as main factors to take into account to select one or another, it is necessary to consider the technology of communications that support such transmissions; and this, at the same time will depend on the parameters of "answers" that we require for such communications (latency and time of answer, delay, channel congestion, throughput, etc).

Now, these parameters will also have to take into account not only the capacities of coexistence but also of collaboration using the hybrid nodes as true gateways among nodes of different technologies.

Now, we also meet with technologies based on Smart Objets (nodes with minimum computing powers but able to communicate the data that they process to other nodes that work as gateways); Ad hoc networks in urderground spaces and confined areas: Let us imagine a characteristic scenario that can be found: kilometers away from the marine surface, immense drills of an oil platform open themselves to hundred of minuscule spider robots that not only control and direct the excavation, but they also exchange among them the information "to analyze as a team" the situation and the status of their work. Once the concerning problems of communication among the nodes are overcome (and of course, those originated by the physical conditions), we should focus ourselves in the individual behavior and mainly the group behavior that our sensor robots will assume; support for Inter vehicle communications: A vehicle could establish communications at short distance with other vehicles and bases stations with IEEE 802.15.3; and when going away, in order not to lose covering, it will communicate via WIFI or 802.11h, depending on the standards approved in the region where the vehicle is. The mobile node (vehicle) will have the capacity "to decide" in what moment it will use some of the two available technologies and the form of negotiating the transfer of those communications.

III. Intelligent Hybrid Nodes and Creation of Common Platforms

Description of the device: This should contain a chip capable of communicating using both technologies with the mimimum interference; besides, it should work together with its microprocessor or microcontroler that allows it to execute the application that will provide the intelligence.

It should be coupled with different types of sensors that would give it "bigger perception of the environment"; This device, at the same time, should be able to support processes of collaborative computing (Grid computer) to be able to be part of the collaborative applications that may require it[2].

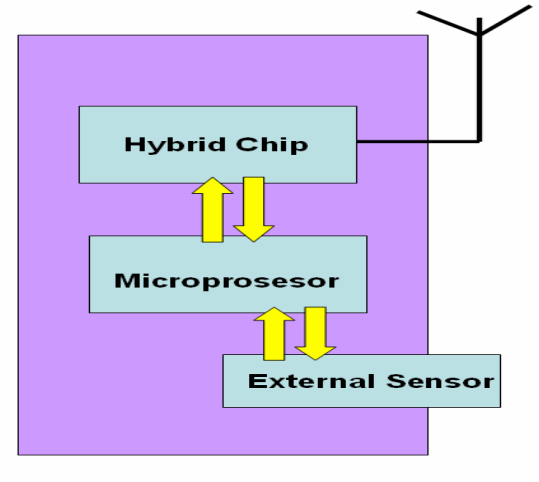

Fig. 2. This device is not completely "idealistic", because they are already in the market wireless telephones with similar characteristics; lacking perhaps the capacity of perception for the sensors.

The problem of these devices is the portability and costs of these components. If we take like an example, a smart Objet, or a wireless sensor network, we would see in both of them the necessity of waiting for these components to adapt to these particular characteristics. The most probable thing is that the first generation of these equipments, to be found in wireless telephones and specialized PDA's, for not naming a laptop equipment enabled with peripherals that transform it into one.

IV. A Common Scenario for the Survival of the Communications among These Devices

Let us foresee the following scenario: 2 nodes that are in the range of communication of both, and that the communication requires the mimimun quantity of energy and computing efforts to transfer information; it will use in that moment the "minor" technology of communications to establish the communication; once one of the nodes or both, begin to move and go away with the real possibility of leaving the range of common covering; in order not to finish the communication, the issuing node will immediately detect by means of specific procedures that this happens; immediately notifying to the destination node the change of "minor" communication type to another that allows it to enlarge that covering range and not to lose the continuity of the communication; beginning in both nodes the necessary functions to adapt the emission and reception of the format of the new packages; as well as the minimizacion of losses caused by handover and overflow of lines.

ISBN:978-988-17012-6-8

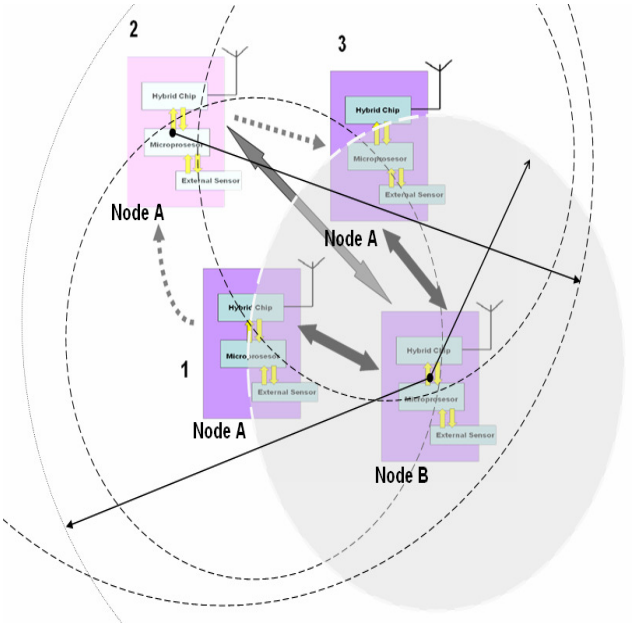

Fig. 3. Real situation for the application of intelligent hybrid nodes; in 1, the A node is in range of "minor communication" with the node B; then it moves and it leaves this range (2), for what both nodes are in "major communication", before having arrived to that moment, both nodes should have begun the "adaptation" to the new communication process; in the 3 position, the minor communication has been reestablished.

If the nodes enter again in the covering where the "minor" communication technology can be again activated; it will begin the mechanisms to adapt and to drive again the flow of data in that format.

V. HYBRID NODES IEEE 802.11H / BLUETOOTH

Let us remember that these nodes consist on devices capable of not only to transmit simultaneously in both technologies, but of being capable "to decide" in what moment of the transmission it can change the technologia of communications; at the same time that is able to negotiate the produced handover (Buffering, handling of lines, lost of data, etc). Here, and according to what was explained in the previous line, we would assume a Bluetooth technology as a "minor" one (for costs, easiness to develop applications, availability in market) and to IEEE 802.h as"mayor" (a substantial advantage with IEEE 802.11b is that it does not interfere with Bluetooth[3] to work in different frequency and to have the mechanisms to minimize it if it appears, but regrettably, it is still in experimental phase), that is to say, the technology that would allow us to communicate at larger distances.

Wi-Fi uses DSSS with a 22 MHz passband, and communicates with throughput up to 11 Mbps. A Wi-Fi system can use any of eleven2 22-MHz wide sub-channels across the available 83.5 MHz of the 2.4 GHz frequency band. Because Bluetooth hops on 79 of the available 83.5 1-MHz channels, and Wi-Fi occupies 22 1-MHz channels within its passband, sharing between the two technologies is inevitable. Two wireless systems using the same frequencynband will have a high propensity to interfere with each other.

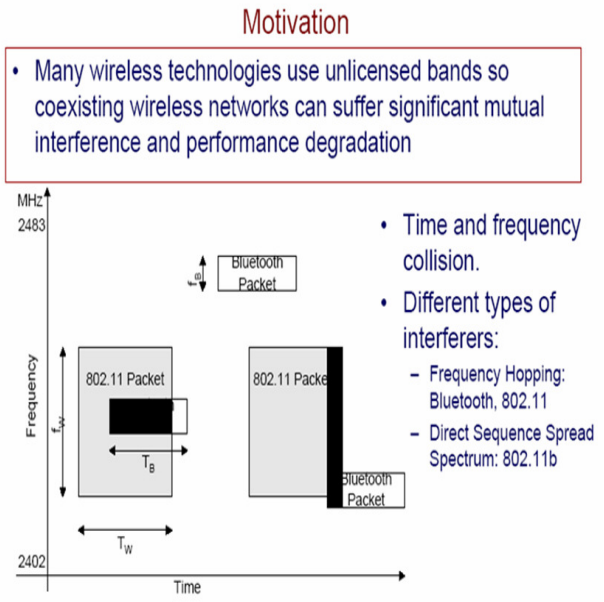

Fig. 4. Interference between Bluetooth and IEEE 802.11b

Bluetooth requires that a low-cost transceiver chip be included in each device. The tranceiver transmits and receives in a previously unused frequency band of 2.45 GHz that is globally available (with some variation of bandwidth in different countries). In addition to data, up to three voice channels are available. Each device has a unique 48-bit address from the IEEE 802 standard. Connections can be point-to-point or multipoint. The maximum range is 10 meters. Data can be exchanged at a rate of 1 megabit per second (up to 2 Mbps in the second generation of the technology). A frequency hop scheme allows devices to communicate even in areas with a great deal of electromagnetic interference [4].

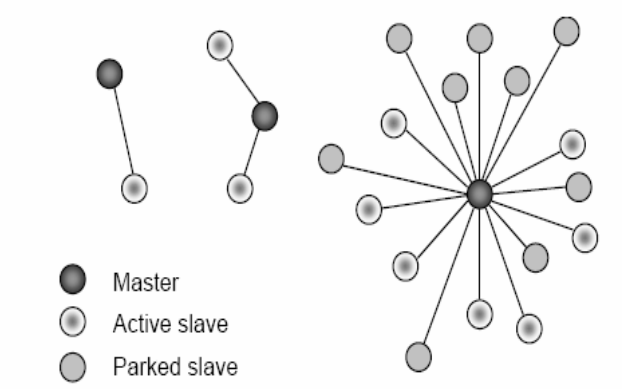

Fig. 5. Piconet configurations

Bluetooth does not require the predefinition and planning, like with a standard net: their interconnection is immediate, as soon as a node is detected by the other ones. The devices of a Bluetooth system are automatically organized into groups from two to eight: the piconet. In a piconet, only one device has a teacher's function and the others the function of slaves. Two slaves of a piconet cannot communicate directly among them, they can only make it with the teacher.

Several piconets can form a scatternet, being able to be the bridge among them any of the involved nodes that are between the mutual transmissions ranges [5].

When entering a Piconet, a slave waits for an *Inquiry* message from the master to learn the master's address and clock phase, which it then uses to compute the hopping sequence. The transmission channel changes 1600 times per second; this means that the transmission frequency remains unchanged for 625 ms long *slots*, which are identified by a sequence number.

The master station starts its transmissions in the even slots, the slaves in the odd ones. A message may last for 1, 3, or 5 consecutive slots. The channel used to transmit *multislot* messages is the same one used for the first slot of the message: this means that the hopping sequence does not advance when transmitting multislot messages.

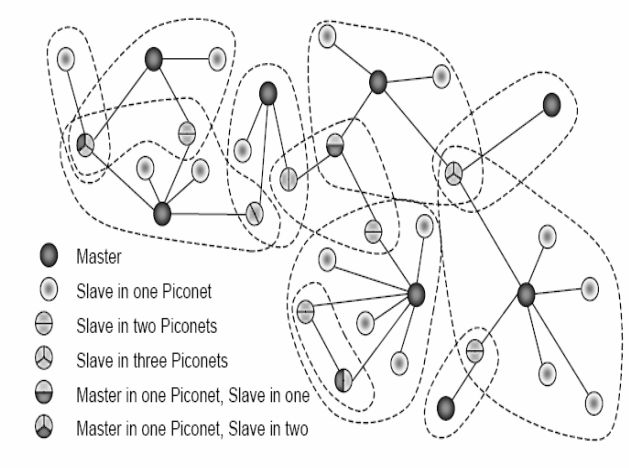

Fig. 6. A complex scatternet configuration

The question has been asked about Bluetooth, and its use in (fast) moving objects . For example:

- If two cars pass and are only within contact range for 800 µs, will they be able to connect every time, or only those times when within contact range for a certain amount of time

First of all, it is difficult to specifically calculate the worst case timing for the connection, as the master will keep on sending the train of DACs at different hop frequencies during paging, until it receives a response from the slave or the time-out pageTO is exceeded. Also Bluetooth doesn't compensate (and wasn't specifically designed) for Doppler effects, fast moving echoes, etc. although Doppler effect would be minimum for radio waves in the GigaHertz range. Some companies, such as CrossLink & BlueTags envisage using Bluetooth chips in moving objects, (luggage, containers etc.), so the use of Bluetooth in moving objects certainly seems possible .

802.11h is intended to resolve interference issues introduced by the use of 802.11a in some locations, particularly with military radar systems and medical devices. Networks using 802.11h operate at radio frequencies between 5.725 GHz and 5.850 GHz. The specification uses a modulation scheme known as orthogonal frequency-division multiplexing (OFDM) that is especially well suited to use in office settings. In 802.11a, data speeds as high as 54 Mbps are possible. There is less interference with 802.11h than with 802.11b, because 802.11a provides lives available channels, and because the frequency spectrum employed by 802.11b (2.400 GHz to 2.4835 GHz) is shared with various household appliances and medical devices.

VI. HYBRID NODES IEEE 802.11H / 802.15.

Whereas 802.11b technology, which utilizes the 2.4GHz spectrum, is designed to cast a relatively narrow bandwidth over a roughly 300 foot area, 802.15.3 is structured to offer an extremely wide bandwidth over a much more limited area. It is for this reason that 802.15.3 is classified as an 'ultra wideband' wireless technology, as opposed to generic Wi-Fi. Not only is UWB capable of shuttling multimedia-heavy data at speeds in excess of 100M bits/sec, but it is also more capable than Wi-Fi when it comes to penetrating walls and physical barriers, at least over its short-distance transmission area.

The data rates vary among different wireless alternatives (802.11b vs. 802.11g vs. UWB and so on) because of the assigned frequency on which these signals travel, the power requirements, and the techniques used to transfer information. For example, Bluetooth transmits on the same frequency as 802.11 systems (2.4GHz), but relies on much lower power requirements than Wi-Fi, so the range and overall speeds are limited. (We might add that there are plans in the works to unveil a 100 Mbps version of 802.11 at some point, but back to 802.15.3 and UWB).

We have said that 802.15.3, like its other 802.15 brethren and 802.11b networks, operates in the 2.4-GHz unlicensed frequency band. It specifies raw data rates of 11M, 22M, 33M, 44M and 55M bit/sec. The highest rate will reportedly support low-latency, multimedia connections and large file transfers, while 11M bit/sec and 22M bit/sec rates reportedly target long-range connectivity for audio devices. For quality of service, the standard specifies the use of Time Division Multiple Access.

Besides, UWB has some interesting properties that could be useful for short range applications (high throughput, interference robustness, low power, position location

capability, flexibility).

Compared to Bluetooth:

Get much higher data rates

- Under optimal conditions, Bluetooth is a 1Mbps signaling technology.
- Bluetooth is increasing signaling data rates, to 4Mbps.

Much lower transmit power

- Bluetooth is 1mW
- UWB variations are 5-10 times lower

Besides

Mobile Internet access for handhelds

- Comparable or higher speeds than WiFi 802.11n will exceed 100Mbps
- Lower RF power (100-200 uW vs 50 mW) than WiFi
- Higher spatial capacity (bps/square meter)

Fast wireless peripheral access

- Transfer photos, files, music, video
- Stream audio and/or video

The high speed and their access characteristics would allow a true collaboration between the devices, without the limitation of "bottle neck" that arouse with the Bluetooth. Therefore, We would recommend IEEE 802.15.3 as a "minor" technology for the architecture pattern that we have thought about [6].

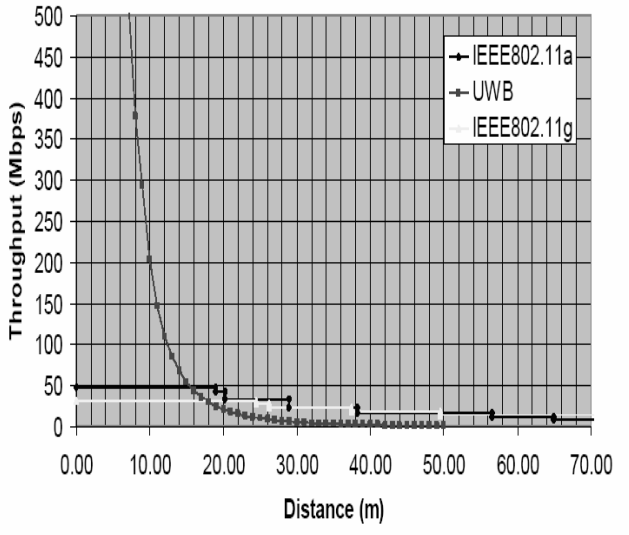

Fig. 7. Performance of UWB with realistic link budget Assumptions. shows significant throughput potential at short ranges.

VII. CONCLUSIONS

We have outlined the possibility to establish the architecture of "intelligent hybrid nodes" as a possible answer to the problems of coexistence and collaboration between mobile equipments. We check some possible real applications for this type of devices and how they could give an appropriate solution for them; we describe one of the real situations where this architecture could be applied; we give a quick introduction to the characteristics of the IEEE 802.11, Bluetooth and the ultra wideband (UWB IEEE 802.15.3) technologies.

In the proposal of the hybrid node 802.11h/Bluetooth, we understand that big efforts have been made in the industry in order to minimize the interference problems among them (especially industrial environments), even above very established technologies in the market as WIFI (IEEE 802.11b).Unfortunately, the fact that there is a so disproportionate difference referring to the transmission capacity between both, as well as the problem related to the aspect of mobility in nodes Bluetooth, as well as the field of this technology when speaking of the routing problem between different piconets and scatternets (topics with pending answers for practical applications) it makes us think that this platform could have applications specifically in the field of the industrial telecommunications, where machineries in movement, interconnected by control systems and with great quantity of interferences and noises, need minimum speeds of information transfer (data control, sensors, etc) but if they always stay active [7].

About the hybrid nodes 802.11h/UWB 802.15.3 we would give answer to those situations where a high capacity of data transfer among the devices of the outlined heterogeneous net is required (802.15.3 is the IEEE standard for high data rate WPAN designed to provide Quality of Service (QoS) for real time distribution of multimedia content, like video and music. It is ideally suited for a home multimedia wireless network. The original standard uses a "traditional" carrier-based 2.4 GHz radio as the physical layer (PHY), also, it facilitates us the routing process , in great measure, the current algorithms could be well applied for ad hoc nets already known for IEEE 802.11 (AODV, DSR, Zone Routing Protocol,etc) or to think about the development of new algorithms based on processes of artificial intelligence that take out the maximum profit of those processing capacities and characteristic interaction with the environment that possesses the hybrid node[8]. However, the fact that both technologies are still in their early stages, foresee that a long time will be needed in order to find devices that use them; even, UWB is not the only personal area networking (PAN) game in town. There is also a technology called ZigBee (802.15.4), which utilizes a variety of licensed and unlicensed bands worldwide, operates on extremely low power, and is positioned for control and remote management applications.

The future role for investigators in M2M Networks would be better quality of service (QoS), increase mobility support and new industrial applications using special startegies, like artificial intelligence; these new implementations will be use in Ad hoc networks and relay based cellular networks [9]; Only the experimental and investigation results, together

with those future "visions" future of the big companies that sell this type of technologies will indicate us which solutions will be the ones that will stay in this new world of the so called nets of fourth generation, or 4G.

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