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Scenario Descriptions for Localisation Application for Home Audio Systems

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Abstract

The UWB location detection capabilities can be explored to enhance the capabilities of smart audio systems by providing knowledge of features such as positions of multiple loudspeaker boxes (relative and absolute) and certain room properties (e.g. absorption characteristics) to be extracted .

This opens up certain possibilities to automate and simplify certain setup procedures, as well as improve characteristics of the audio system according to the measured/detected conditions.

In this document several application scenarios for using this information will be described, together with their specific advantages for the end user.

Keywords

UWB, localisation, ranging, home theatre system, multiple speaker systems, Ambisound

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Abbreviations

EUWB	CoExisting Short Range Radio by Advanced Ultra-WideBand Radio Technology
LT	Location Tracking
HTS	Home Theatre System

1 Executive summary

This document proposes three application scenarios that provide the focus of EUWB's location tracking activities within the home environment cluster. These include:

- Multiple speakers Home Theater Systems (HTS)
- Two-point Ambisound Systems
- Single-point Ambisound (Soundbar)

For each of the applications a statement of problem is made and areas that UWB location tracking feature can help address the related issues are identified.

The nature of the proposed applications would require different approaches to provide localization information and as such work on possible solutions should be addressed within different work packages within the EUWB project.

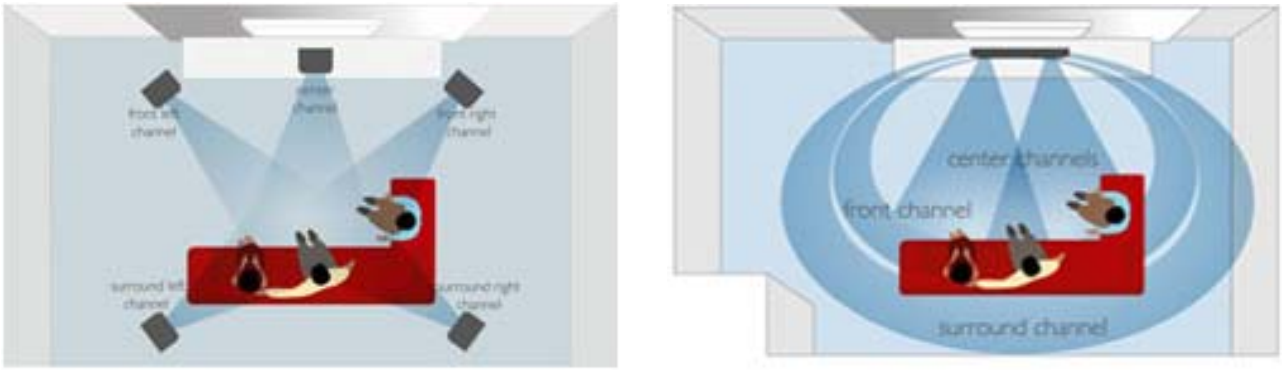
2 Introduction

One of the key parameters by which performance of a home theatre system is evaluated is its ability to reproduce an audio experience that is faithful to real experience in immersiveness and perception of directionality. This is conventionally achieved by re-routing of sound components to relevant multiple speaker boxes distributed in a certain constellation. For this to work well a number of external parameters are required to be known by the system such as the number of speaker boxes, their relative position, their orientation and the location of the listener.

From the consumer point of view, a good consumer electronic product needs a simple set up procedure that requires little effort before an optimum performance is reached. In the case of a home theatre system this implies much information about the operational environment and arrangement of the system would ideally be derived in a smart, adaptive and automated manner.

There are various techniques that potentially can solve this problem but they all have practical limitations or undesirable features. This has resulted in no promising (and cost effective) solution to be currently available in the consumer market. UWB-LT can be considered as a potentially promising technology that can enable audio designers to achieve this goal.

Another important aspect of home entertainment systems is their design appeal. In the case of multi speaker home theatre systems one undesirable design issue is the clutter of necessary connecting cables. There has been much effort spent in achieving immersive surround sound without the constraints of room shape (or size), and without the clutter of multiple speakers and cables. Ambisound technology is one successful technique developed by Philips that achieves this goal through the combined effect of three mechanisms: array processing, precisely angled driver positioning and psychoacoustic phenomena [3]. **Figure 1** compares the Ambisound concept with the conventional 5.1 surround sound system.



(a) (b)

Figure 1 - Surround sound from a) Conventional 5.1 system and b) Ambisound system

For the UWB-LT to help optimise the performance of single bar ambisound system, a completely different approach to that necessary for multiple speaker systems would be required.

This document will outline three application scenarios that can benefit from automatic and adaptive location and ranging information but require completely different approaches to provide this information.

3 Application Scenarios

3.1 Home Theater systems with multiple speakers

3.1.1 Problem description

In a ‘standard’ Home Theater System setup (see Figure 2), multiple speakers (e.g. 5.1) are used to reproduce the surround sound.

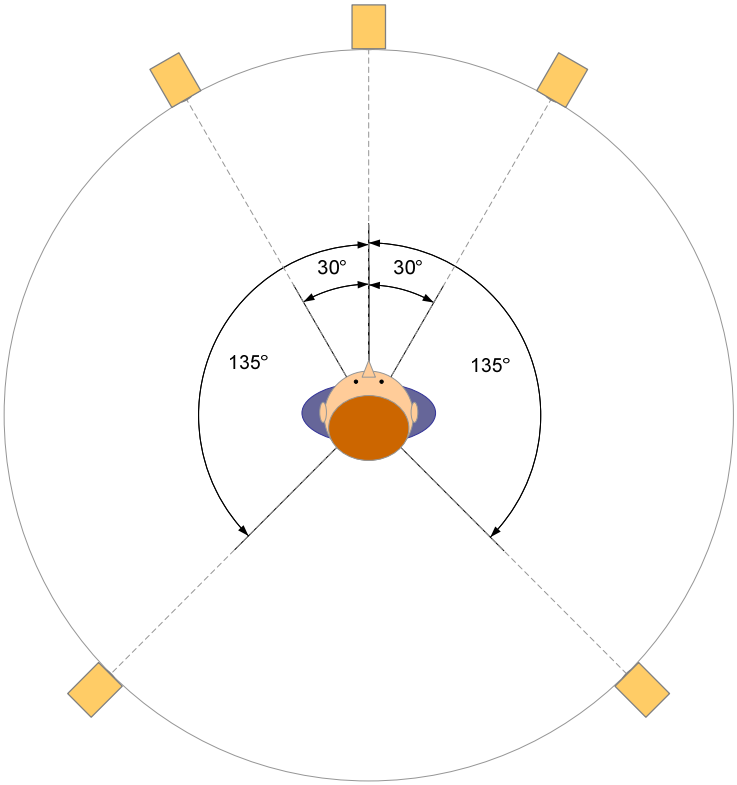


Figure 2 - Ideal 5.1 speaker setup

Even from the early days of this kind of audio systems, several aspects needed to be known for a correct setup to reproduce the full experience. Initially, these settings were done manually. Later, several automated systems were introduced, mostly using an external microphone.

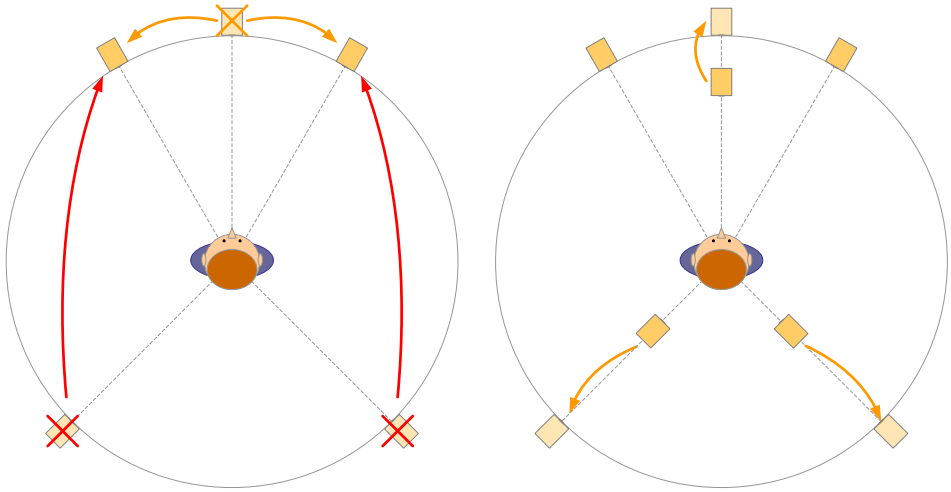
Typically the following parameters are available to the user when doing a manual setup:

- number of installed (satellite) speakers: enables the down mixing (re-routing) of Center, Rear or Subwoofer signals when the speaker(s) in question are not installed (see Figure 3a)
- distance of the speakers from the listener: introduces delays when one or more satellite speakers are placed closer than on the ‘equidistance circle’. (see Figure 3b)
- relative level of each speaker: adjustment to compensate for loudness differences due to differences in distance, speaker sensitivities, different placements etc. (see Figure 3b)

- speaker sizes: for some of the satellite speakers (Center and Rear), smaller speakers can be used. In this case, the lower frequencies belonging to these channels are re-routed to the Front speakers and/or Subwoofer.

In most systems, however, there are still some limitations and other parameters that are not easily detected / corrected:

- It is generally not possible to delay the Front speakers, so it is e.g. impossible to correct for Rear speakers that are positioned further away than their correct position
- The delay for the Rear speakers is generally the same for Left and Right, so it is not possible to correct them individually when one is placed closer than the other



(a) **(b)**

Figure 3 - a - Missing speakers; b – Delays and level adjustments

Automated setup systems using an external microphone are capable of setting most of these parameters fairly easily and quickly. Some of them are even capable of detecting/measuring some other items like room parameter for corrective EQ. The more expensive systems have also some more flexibility concerning delays, and are thus able to adjust this for each speaker individually, including the Front speakers and sometimes even Subwoofer.

However, the use of one single measurement microphone still has some intrinsic problems:

- There is no way to see whether the speakers are placed on their expected position. For example if Left and Right (or even Front and Rear) are swapped, this cannot be detected.
- The angles of the speakers cannot be measured, which can still compromise the sound image if not setup correctly.
- If the microphone is positioned incorrectly (i.e. not in the listening position and/or not at ear height), the results after calibration can be worse than before.
- If the speaker setup is slightly changed, the complete procedure needs to be rerun again.

3.1.2 Possible applications for UWB

Using UWB position detection, the following parameters could be detected / measured and corrected.

- **Speaker presence**: if every speaker is considered as a node, it becomes possible to detect the number of speakers in the setup. This allows to (dynamically) re-route/ down-mix the signals of missing speakers to those that are installed.
- **Speaker size**: using a status response, each node can tell the center unit what its frequency response is. In its most simple form, this is an indication of the size of the speaker (large/small). However, in its most complex form this can be the low frequency cut-off frequency or even the complete frequency response. The latter then allows for complete equalization of the system.
- **Speaker position**: By measuring the position of the speakers, several settings can be easily calculated and correctly set.
    - Relative distances: In its simplest form, the relative distance of each speaker from the listening position is measured, e.g. by using a beacon in the remote control. That way, the delays and levels can be set correctly, resulting in an already much more balanced soundstage.
    - Absolute positions: if the absolute positions of the speakers in the room are known, the complete soundstage can also be remixed / repanned to better approach the correct speaker positions. This also enables to possibility to use more generic, wireless speakers that automatically ‘recognize’ their role (being a Front, Center or Rear speaker) in the setup.
- **Listening position**: If on top of this information, also the exact position of the listener is detected, some complex remixing/rerouting can be performed to recreate the exact surround setup around the listener as if all speakers were positioned according to the ‘rules’ (see Figure 4).

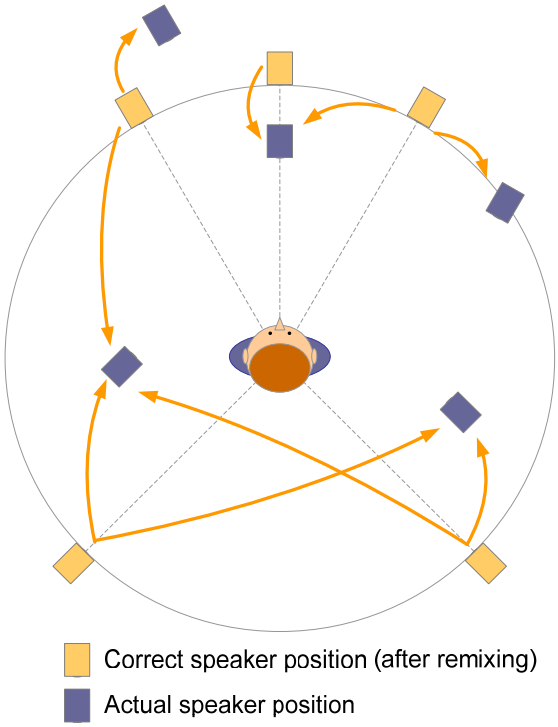


Figure 4 - Example of complex rerouting/remixing

3.1.3 Some advantages of using UWB Position Detection

When comparing the use of UWB Position Detection versus other methods, the following advantages can be noted:

- no need for microphones to be built-in in each speaker box (a solution that also enables the complex rerouting described above, apart from the listening position detection)
- dynamic system: allows for the system to quickly adapt to changing setups (continuously or by pressing a button)
- no need for additional hardware: comes for ‘free’ with hardware to make speakers wireless (which will mostly be the primary role of UWB).
- invisible to the user

3.2 Two-point Ambisound Systems

3.2.1 Problem description

A two-point Ambisound system uses two specifically-designed speaker boxes to reproduce a surround sound experience. The placement of these boxes versus the listening position is therefore very important, though not critical, for the best listening experience.

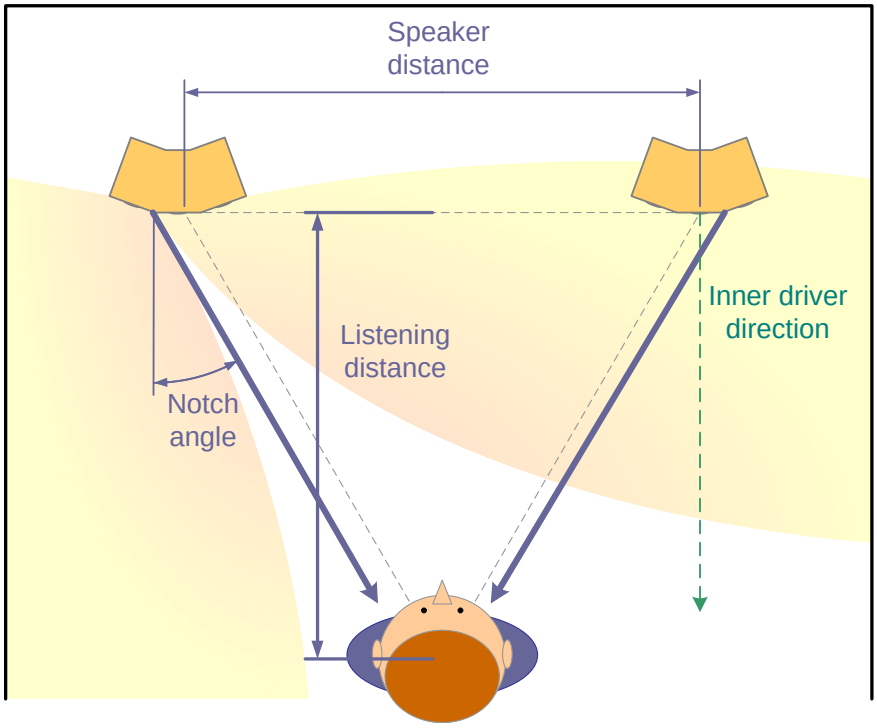


Figure 5 - Two-point Ambisound ideal setup

Ideally, the listener is sitting exactly in the middle of the two speaker boxes. The drivers in the middle of the boxes (inner drivers) should be pointing perpendicular to the axis between the two drivers.

The ideal listening distance is between 1 to 2 times the speaker distance, with the notches angled directly to the listener. The two boxes should also be positioned at equal distances from their respective side walls.

Currently, Ambisound systems provide the following setup parameters:

- Speaker distance: near (<1m)/default (1-2.5m)/far (>2.5m)
- Listening distance: near/default/far
- Wall properties (Room Acoustics): hard/soft

However, the system could also benefit from other information, e.g. if the listening position is right in the middle of the speakers or rather more to one side (left/right). This is also called the 'lateral offset'.

Other information that is currently not taken into account:

- position of each driver in relation to the sidewalls
- relative distance of each speaker box from the listening position, which is actually related to the lateral offset of the listening position as described above. This information can then be used to add some additional delays where needed, as well as to set the relative levels of the speaker boxes

3.2.2 Possible applications for UWB

Apart from the obvious step to use the high bit-rate streaming capabilities of UWB to make the speakers wireless, it also offers some position detection possibilities.

Using UWB position detection, the following parameters could be detected/measured and corrected:

- **Speaker position**: By measuring the position of the speakers, several settings can be easily calculated and correctly set:
    - Relative distances: In its simplest form, the relative distance of each speaker from the listening position is measured, e.g. by using a beacon in the remote control. That way, the delays and levels can be set correctly, resulting in an already much more balanced soundstage.
    - Absolute positions: if the absolute positions of the speakers in the room are known, several parameters can be calculated from this information
        - Speaker distance: the distance between the two speaker boxes: needed together with the listening position to calculate the correct notch angles.
        - Distance from each speaker box to their closest wall: can be used to adjust the relative amount of direct and indirect sound more precisely
- **Listening position**: as stated above, when the exact listening position in relation to the speaker boxes is known, it becomes possible to calculate the notch angles much more accurately than with the rough settings provided by the currently existing manual setup.
- **Wall properties**: by detecting/measuring the reflective/absorptive properties of the walls, a more precise compensation can be performed than with the current two settings (hard vs. soft)

3.2.3 Advantages of using UWB Position Detection

Since currently, there is no real automated setup procedure available for Ambisound products, the use of UWB can provide the following advantages.

- finer control over certain Ambisound-related paramters that are now set manually by the user in very rough (black & white) steps
- dynamic system: allows for the system to quickly adapt to changing setups (continuously or by pressing a button)
- invisible to the user

3.3 Single-point Ambisound (Soundbar)

3.3.1 Problem description

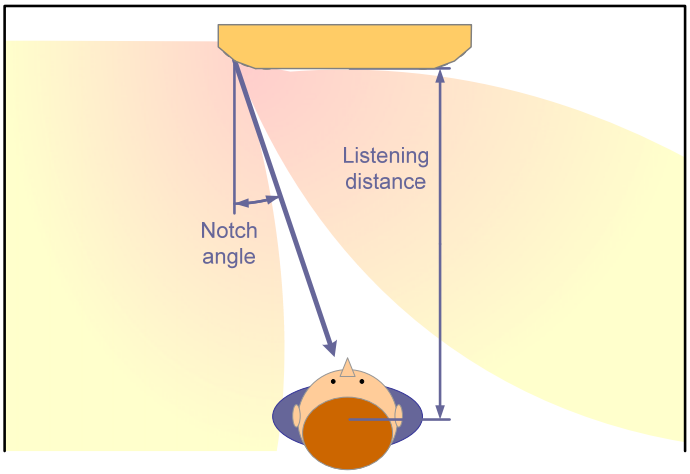


Figure 6 - Single-point Ambisound ideal setup

The setup of an Ambisound Onebar (ie a one-point Ambisound system) is very similar to the setup of a 2-point system. For more details on the several parameters, see section 3.2.

A one-point system, however, has the advantage that some parameters are fixed/known on beforehand by design. The speaker distance is such an example.

The set of parameters that needs to be detected is a bit smaller.

- Bar position: distance from the sidewalls, detection of corner placement
- Listening position: both listening and lateral distance
- Wall properties; hard - soft

3.3.2 Possible applications for UWB

Using UWB position detection, the following parameters could be detected/measured and used for audio optimisation:

- **Bar position**: By measuring the position of the bar in the room, several parameters can be adjusted for a better performance
    - **Distance from the sidewalls**: this can be used to see whether the bar is positioned in the middle of the room or rather closer to a sidewall. This information can then be used to optimize the balance between direct and indirect sound for the best experience.
    - **Corner placement**: this is actually a special case where the sidewalls are virtually too far to be usable for the Ambisound effect.

- **Listening position**: as stated above, when the exact listening position in relation to the bar is known (both the distance and the lateral offset), it becomes possible to calculate the notch angles much more accurately than with the rough settings provided by the currently existing manual setup.
- **Wall properties**: by detecting/measuring the reflective/absorptive properties of the walls, a more precise compensation can be performed than with the current two settings (hard vs. soft).

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4 Conclusions

This document has presented three application scenarios where UWB-LT capability can benefit consumer electronic applications within the home environment.

Each scenario poses a different challenge which in turn requires a different approach necessary to achieve the goals. These will be considered within the home cluster of the EUWB project.

The different approaches however have to fulfil some common challenges: reliablity, adaptive to different environments/conditions and low implementation complexity.

References

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[3] http://www.ambisound.philips.com/en/gb/ambisound.html

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