stage of environment signals and sources parameters detection. In this case, the estimation and detection is used to acquire information on several signals to make a selection decision. The purpose of this work is to create a complete multiagents system able to detect environmental sources and listen to them simultaneously. In our case, multi-agents systems are presented as new paradigm used to design intelligent independent systems. To accomplish this specific task, several agents with different goals, must cooperate on the system. In this paper we are using arbitrary 3D architecture array sensors combined with multi-agents systems. By this approach we are implementing cooperating agents for detection and beamforming.

2 ARRAY SENSORS MODELING

Array sensors are formed with multiple elementary sensors, each one with a geometrical position in space and considered as independent observer in respect to a well-defined origin as shown in Figure 1 [1-7]. Each sensor provides a measure, if the array is composed with "N" sensors then the overall answer of the array will be writes in vectorial form by (1) [2,7]:

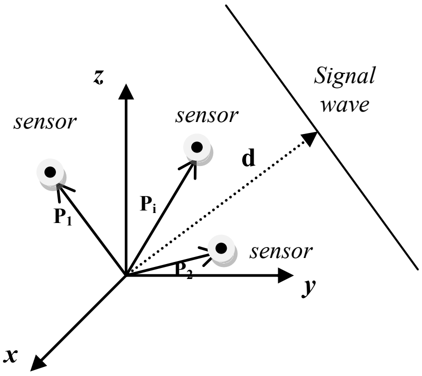

Figure 1. Array sensors general disposition [2,5-7].

$$X(t) = \begin{pmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_N(t) \end{pmatrix} \quad (1)$$

2.1 Propagation channel modeling

The propagation channel is defined as the medium used by the different signals between transmitters and receivers [1,2,6-10]. Ideal connection is achieved if the received signal is exclusively the same as the emitted one without distortion. Alas, in reality the channel will alter the signals by adding: noise, attenuation, fading, absorption, dispersion, refraction, reflection, Faraday rotation, glitter, Dependence of polarization, Doppler Effect, and multipath (see Figure 2) [1,13,14].

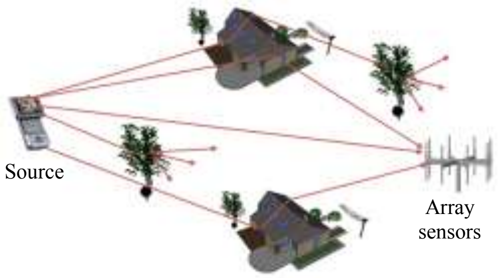

Figure 2. The channel: fading, absorption, dispersion, refraction, reflection and multipath, effects.

We have used the block diagram shown on Figure 3, to simulate the channel effects. In this diagram, we model the multipath, fading and time propagation effects by equation (2) based on narrowband signals [2].

$$h(t,\tau) = \sum_{i=1}^{N} x(t) e^{j\varphi_i(t)} \delta(\tau - \tau_i(t)) \quad (2)$$

With *x(t)* signal from the emitter, $\varphi_i(t)$ path rank *i* propagation phase shift, $\tau_i(t)$ path rank *i* temporal delay.

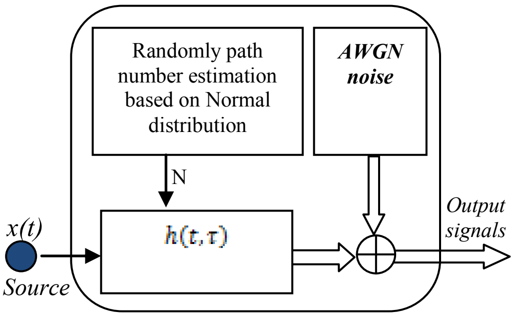

Figure 3. Implementation synoptic for channel: multipath, fading, propagation delays and noise effects.

2.2 Array sensors signals specifications

The array response, detailed by equation (3), is a linear composition of the noise *B(t)* and $S_i(t)$ the incident signals on the array sensors.

$$X(t) = \sum_{i=1}^{L} S_i(t) \qquad (3)$$

Obviously, based on the channel model, the number of incident signals "*L*" is greater than the source number [2,6].

For any signal $S_i(t)$, the various sensors outputs are identical except a certain delay which corresponds to the wave propagation time [2,6]:

$$S_i(t) = \begin{bmatrix} s_i(t-\tau_1) \\ s_i(t-\tau_2) \\ \vdots \\ s_i(t-\tau_M) \end{bmatrix} \qquad (4)$$

with "*M*" the array sensors number.

If we know signal $S_i(t)$ arrival direction specified by the unit vector "*d*" (see Fig.1), the various propagation delays can be estimated by (see Figure 4) [2,6]:

$$\tau_i = \frac{d \bullet P_i}{c} \qquad (5)$$

where *"c"* is the propagation velocity and vector *"P_i"* the sensor rank *i* position.

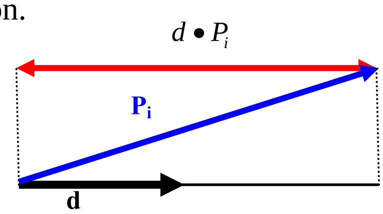

Figure 4. The dot product projection principle used to estimate sensor rank i time propagation delay [2,6].

3 THE DETECTION STRATEGY

In our case the array sensors detection problem is formulated by two points:

- the estimation of the incident signals number "*L*",
- the different arrival directions determination.

To carry out spatial signals separation. Figure 5 describes the strategy we have adopted. The different phases, proposed and implemented, with our strategy are describe on the following sections.

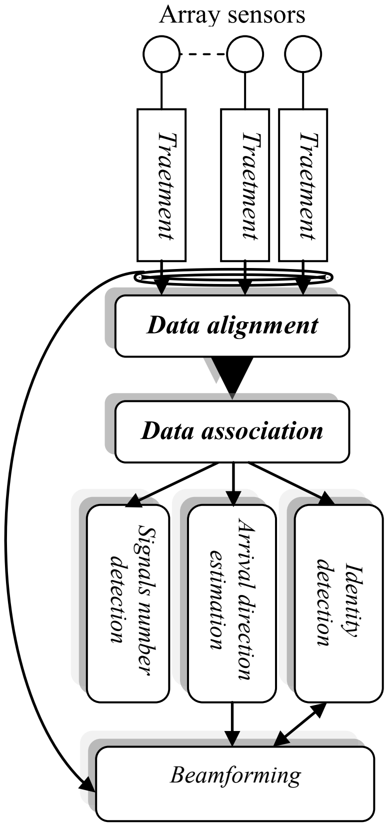

Figure 5. The different phases adopted on the detection spatial filtering strategy.

3.1 Treatment and data alignment phases

In this work we have considered only narrow band signals; the treatment phase will implement a passband filter. However, the alignment phase will perform an amplitude normalization to cope with the channel attenuation phenomena. Practically this is done through emitted power control [11,12].

3.2 Data association phase

In this phase we will regroup the measures from different "M" sensors in a single entity. According to equations (4) and (5) we can write:

$$X(t) = \sum_{i=1}^{L} s_i(t) \times S_i \qquad (6)$$

where S_i denote the array space vector. With narrow band assumption, the array space vector expressed by equation:

$$S_i = \begin{bmatrix} e^{-j\varphi_1} \\ e^{-j\varphi_2} \\ \vdots \\ e^{-j\varphi_M} \end{bmatrix} \qquad (7)$$

with $|\varphi_m| \leq \pi$ propagation phase delay. The matrix notation of the array response can be written by:

$$X(t) = A.[s_1(t) \quad s_2(t) \quad \cdots \quad s_L(t)]^T \qquad (8)$$

where "A" denote the array manifold matrix (9):

$$A = [S_1 \quad S_2 \quad \cdots \quad S_L] \qquad (9)$$

It is now possible to calculate the correlation matrix "R" associated with the measures from the two last phases by (10), which can be expressed with the manifold matrix by the equation (11).

$$R = E\{X(t).X(t)^H\} \qquad (10)$$

$$R = A.S.A^H + R_{GWN} \qquad (11)$$

where "R_{GWN}" the noise correlation matrix. This matrix is diagonal expressed by equation (12).

$$R_{GWN} = A.(\sigma^2.I).A^H \qquad (12)$$

In this case σ^2 represent the noise variance, considered the same as the noise power.

The association phase will estimate the correlation matrix "R" from the different sensors outputs and in a limited observation time "k". The estimated matrix is carried out by [11,12]:

$$\hat{R} = \frac{1}{K}\sum_{k=1}^{K} X(k).X(k)^H \qquad (13)$$

For important "k" values, the matrix "$\hat{R}$" is considered as a good approximation.

3.3 Detection and beamforming phases

The detection phase based on the preceding ones, is divided onto three parts [2]:

- Incident signals number detection,
- Detection of signals arrival directions,
- Identity detection, this part is introduced to correct the multipath effect by removing redundant signals,

The various sensors responses within the network must be combined by a suitable processing method in order to spatially extract the signals on the different detected directions [2]. Indeed, the detection result, specially the detected incident directions, will be used to implement spatial filtering approach based on a geometrical Smith algorithm or quadratic error optimization [2,7]. The beamforming phase, after acquisition and demodulation, cooperate with the identity detection to remove redundant signals or improve the acquisition quality.

4 MULTIAGENTS IMPLEMENTATION

Multiagents systems with the characteristics of artificial intelligence, collaborations, proactivity, autonomy, and data exchange capabilities, provide us, an interesting opportunity to implement the above strategy. The major problem encountered concern the roles to be played by the different agents in order to meet the overall detection and simultaneous acquisition objectives. The proposed architecture exploits the logic, reactive and BDI multi-agents architectures [2,16]. The intelligence and roles played by the different agents as well as predominant behavior of our multi-agents system, implementing the strategy of figure 5, are shown on Figure 6, with an indication of the main conversations exchanged.

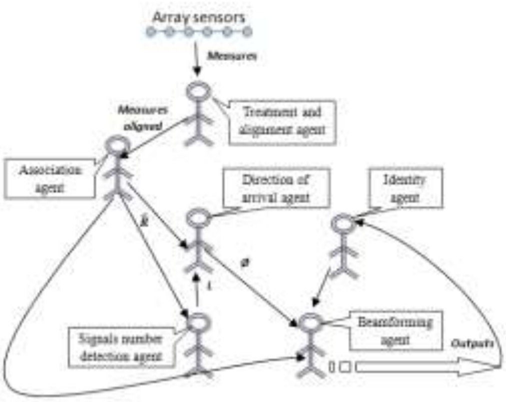

Figure 6. Predominant behavior proposed for our multi-agents system.

5 SIMULATIONS AND RESULTS

We have done simulations for different array sensors architectures. Some results were previously presented on different publications (see [2, 5, 6]). We present in Figure 8 the beam patterns for 10 sensors linear array (Figure 7); the signals arrival directions are imposed to [-75°; 20°; 40°]. The results shown in Figure 8 shows levels between -70dB and -80dB for directions detected corresponding to the assumed ones.

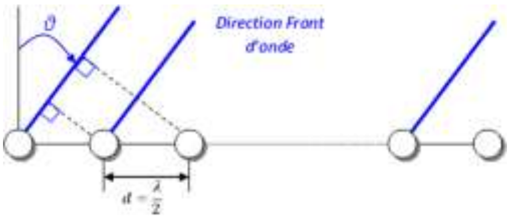

Figure7. Linear uniform array sensors disposition [2,5].

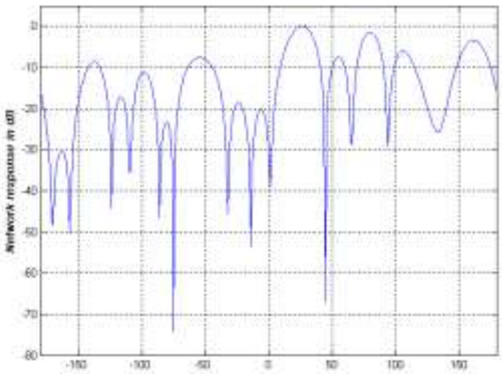

Figure8. Multi-agents Detection done with linear uniform array sensors with -75°, 20° and 40° arrival directions, 20° made-up as useful direction.

The multi-agents detection done with regular planar array Figure 9, is shown on Figure 10 for planar array of 16 elements (4 *X* 4). In this case three sources were simulated according to the directions (-30 °, -60 °), (50 °, 30 °) and (10 °, 10 °). The directivity obtained and the detected directions represented in Fig.10 show that the multi-agents reacts according to the environment directions.

6 CONCLUSION

The theme of intelligent array sensors has received a particular importance, especially with the growth of wireless devices. The interest is mainly due to integration of modern signal processing, detection and artificial intelligence. In this issue, we have addressed the problem of intelligent detection and spatial filtering based on multi-agents systems associated with generic spatially distributed array sensors. However, the presented results are limited to narrowband signals. The problem addressed in this paper deals with three main topics: the study and modeling of sensor networks with a three-dimensional distribution, their use for environment sources detection and then perform a simultaneous acquisition. The results obtained with this research, show that the proposed multi-agents systems has ensure effective cooperation between the different detection and beamforming techniques avoiding duplications caused by the channel influence.

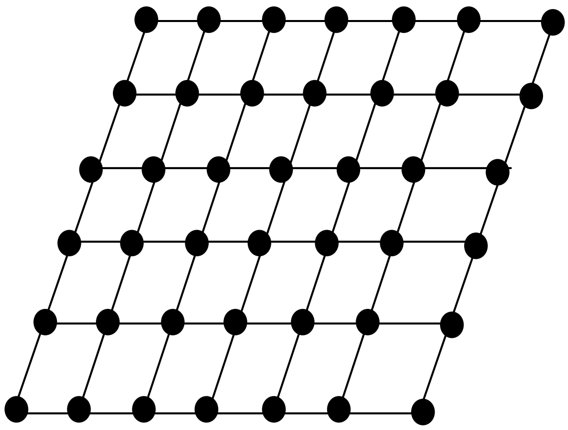

Figure 9. Planar uniform array sensors architecture [2].

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