# MoM Simulation Software in an IoT Scenario with Devices Determining Human Position

Beside typical data exchange, the **EM radiation originating from Internet of Things (IoT)** devices can be processed to provide a number of secondary information which could in turn be used for various purposes. One of the examples could be measurement and processing of signals occurring in an IoT system to realize movement detection or person tracking.

The indoor scenario presented in this application note encompasses the corridor with the ceiling and the floor modeled with metallic plates and infinite PEC plane respectively, a person inside a corridor modeled through a human phantom and three Wi-Fi routers. From the perspective of a position determination scenario, it is interesting to analyze situations where one of three router transmits a signal, while the other two operate as receivers. It is expected that, as a person moves inside the corridor, the received signals will change. **This property could provide a possibility to detect a presence or even determine a position of a human** within a corridor.

Only electromagnetic (EM) aspects of this scenario will be considered here, not the processing of the signals. All simulations will be carried out using **WIPL-D Software**, **a full wave 3D electromagnetic Method-of-Moments based software which applies Surface Integral Equations.** It will be shown that the results can be obtained in acceptable simulation time.

## WIPL-D Models

The complete model of the scenario considered in this application note including corridor with metallic floor and metallic ceiling, with walls modeled as dielectric bricks, human phantom, and three models of Wi-Fi router is shown in Figure 1.

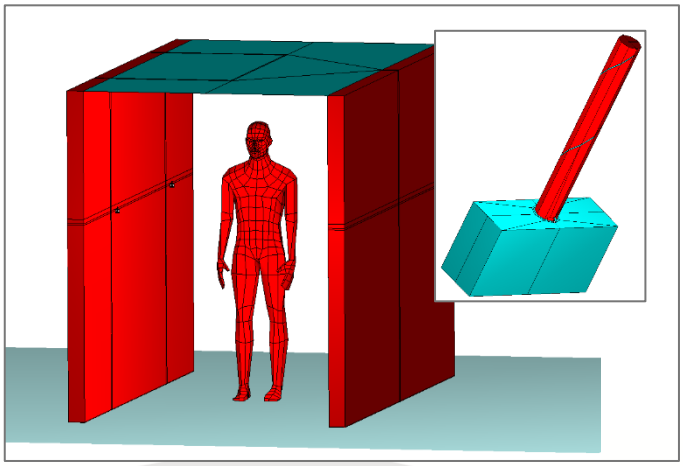

**Figure 1. The corridor with ceil and floor, containing dielectric walls, human phantom, and three Wi-Fi routers**

The magnified view of a model of Wi-Fi router used in the particular scenario is also shown in the figure. The Wi-Fi routers are positioned at a height of z=1.2 meters in such manner that they form isosceles triangle (see Figures 2-3).

Isometric view of the scenario where the phantom moves along the corridor between Wi-Fi routers is shown in Figure 2. The list of the dielectric objects included in the scenario and corresponding electrical properties can be found in Table 1. The properties of all of the materials used are for demonstration purposes only.

**Table 1. Applied materials**

| Object | Er | TgD |
|---|---|---|
| Human phantom | 100 | 0 (Sigma = 3 [S/m]) |
| Helix mast | 2 | 0 |
| Corridor walls | 3 | 0.0167 |

## Simulations and Results

Five simulations were performed, each with a different position of the phantom along the corridor to mimic the human movement. Simulations were carried out at the operating frequency of 2.4 GHz. The signal levels related to all positions of the human phantom were recorded. The bird's view perspective of the corridor indicating five positions of the human body are presented on left-hand side of Figure 3, while the corresponding received signal levels (antenna currents in particular) are shown on the right-hand side.

The results presented in Figure 3 clearly indicate that a judicious processing of the received signals could provide not only the information about the presence of a person inside the corridor, but the position along the corridor as well.

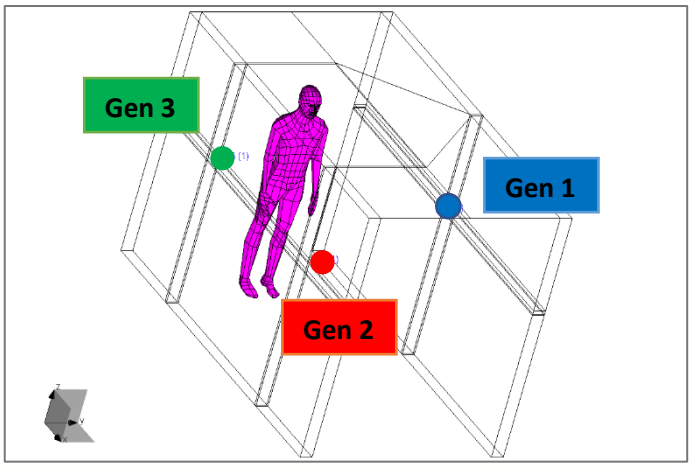


**Figure 2. Isometric view of phantom in the position 1 and generators**

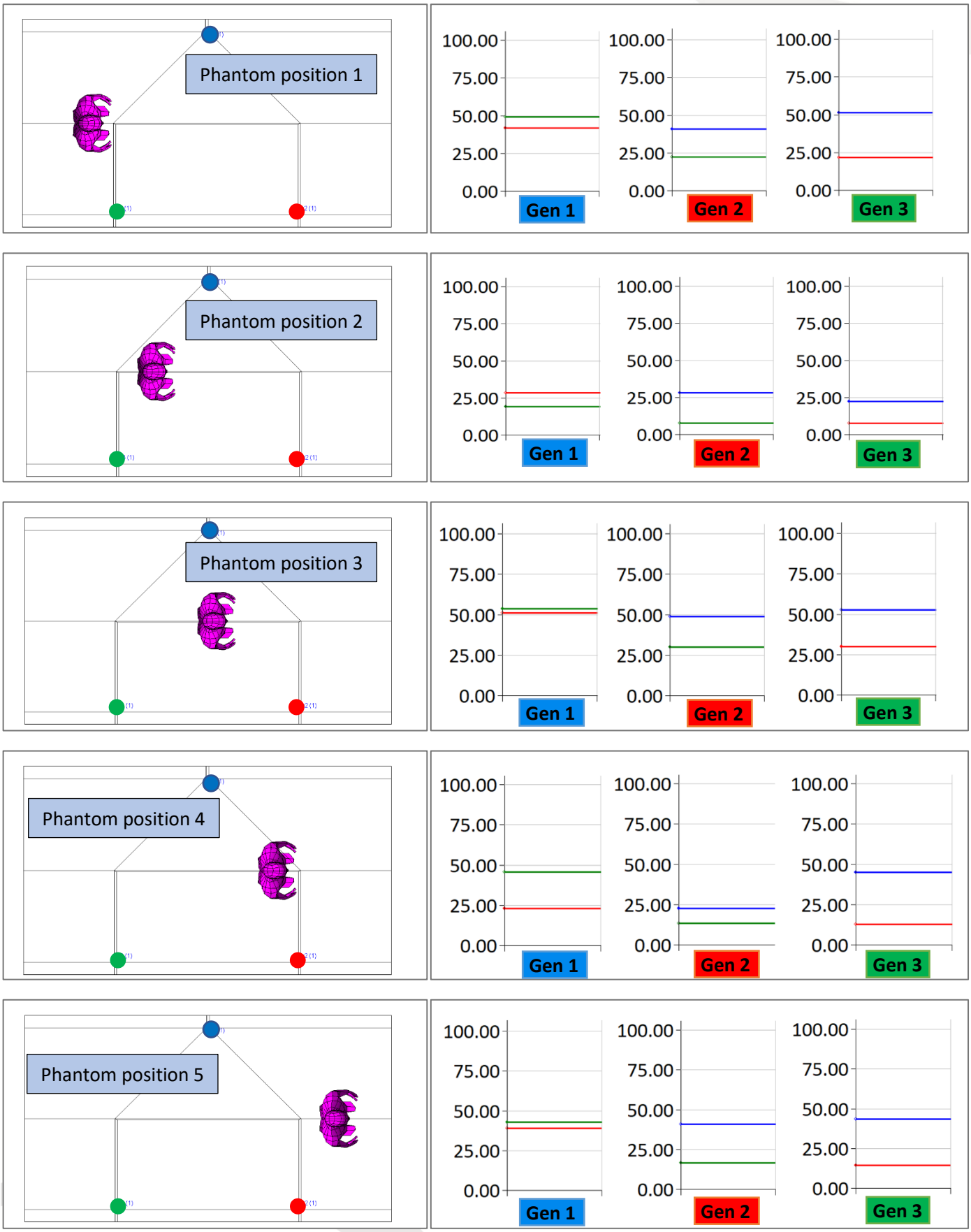


**Figure 3. Phantom positions and levels of the currents**

Computer hardware used for simulations is presented in Table 2.

**Table 2. Computer used in the simulations.**

| Hardware | Description |
|---|---|
| CPU | Intel® Xeon® Gold 5118 CPU @ 2.30GHz 2.30 GHz (2 processors) |
| RAM | 192 GB |
| GPU | 4 cards: Nvidia GeForce GTX 1080 Ti |

Number of elements, number of unknowns and simulation time per one position of the human phantom are presented in Table 3. Matrix fill was performed on CPU. Matrix solution was performed using GPU cards.

**Table 3. Number of unknowns and simulation times for simulated scenario**

| Number of elements | Number of unknowns | Simulation time per phantom position |
|---|---|---|
| 7,648 | 171,489 | 37 min |

## Conclusion

The **2.4 GHz IoT scenario** presented in this application note encompassed the corridor with the ceiling and the floor modeled with metallic plates and infinite PEC plane respectively, a person inside a corridor modeled through a human phantom and three devices which can be part of an IoT network – the Wi-Fi routers. It was assumed that the Wi-Fi routers operated in such manner that one transmitted signal, while the rest of the routers operate as receivers.

It was shown that received antenna signals can be exploited for purpose of **detection of human movement** or even for **determining exact human position** within the corridor. It has been shown that currents on receivers change with a change in person's location within the corridor. In a real-life scenario the **currents calculated using EM simulation** can be used as reference values and compared with those measured on the IoT equipment and the position of a human can be easily determined based on a database of precomputed results.

All the simulations were successfully carried out using **WIPL-D Software**, **a full wave 3D electromagnetic Method-of-Moments based software which applies Surface Integral Equations.** Despite usual approach where similar structures require application of an asymptotic solver, the realistic scenario as describe can be analyzed using a full-wave MoM based solver as simulation time per a phantom position is only about 37 minutes.