Nextechs Indoor Positioning System

an Ultra Wide Band approach

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The Nextechs Indoor Positioning System (NIPS) is an UWB based system for high resolution, high accuracy, 3D location of objects indoor. The system consists of an infrastructure of fixed, active objects called NODES that perform ranging measurements with the objects that are to be located, called TARGETS. Signal time of flight (tof) from nodes to targets is measured in order to compute distances and solve positioning equations. Fast ranging execution, in the order of milliseconds, an efficient system protocol – the NIPP (centralized or distributed), and smart adaptive algorithms allow high density, dynamic targets location, in true real time.

Keywords: *UWB, ToF, Nodes, Targets, NIPP*

I. INTRODUCTION TO THE NEXTECHS INDOOR POSITIONING SYSTEM (NIPS)

The system was originally designed to track lots of silicon wafers in a semiconductor fab. The main requirement was to simultaneously track up to 10000 lots moving inside a class 1 clean room of about 11000 m2, a very challenging task indeed, due to a very unusual high density of process machines, full of reflecting, metallic surfaces. The element target attached to the lot containers, is an active, battery operated circuit consuming the lowest energy for long term operations before recharging. Having in mind to adopt a RF based system, and given all the above mentioned constraints in terms of scale of tracked units and required tracking performances, then the adopted technology had to cope with high positioning speed and low energy consumption requirements. This led to the choice of direct measurements techniques and fast, small duty cycle operations, the former for precision and accuracy reasons, the latter for large scale and performances related reasons.

II. SELECTED TECHNOLOGY FOR NIPS

The choice to adopt an Ultra Wide Band (UWB) based system was mainly dictated by the need of performing operations as fast as possible, in order to setup large scale, real time deployments. The recently introduced DW1000* module by the Irish company Decawave further encouraged the adoption of the UWB approach to design an efficient and scalable indoor positioning system. Based on the DW1000 module, Nextechs has designed a **complete, fast, large scale, 3D, centimetre resolution, high accuracy, self-expandable, real time, power efficient, plug&play, low cost,** indoor positioning system. The active elements in NIPS are industrial grade, small units, that are battery operated and allow to locate and track even small objects, quite efficiently.

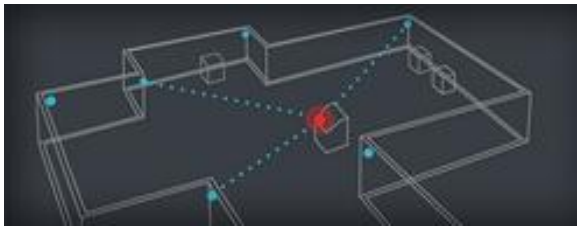
Power Over Ethernet NIPS Node (size 11 x 5.5 cm)

III. SYSTEM LAYOUT AND PRINCIPLE OF OPERATION, SCALABILITY

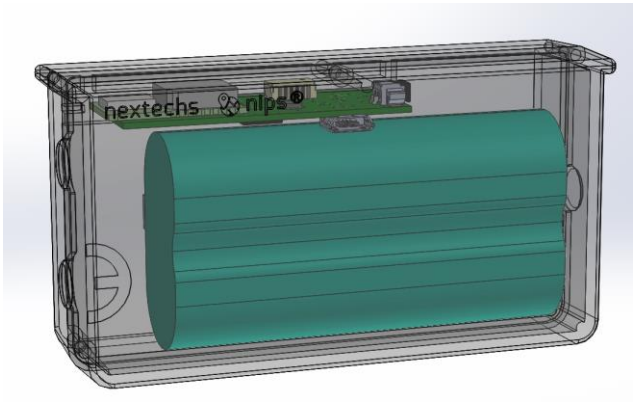
The NIPS system is an infrastructure based solution. Before the system can be operated, reference objects have to be placed inside the building. These objects are called NODES. For accurate positioning it is only important to know, once and forever, the xyz coordinates of the node's antenna centre of phase. This actually is the only really 'complex' stuff one has to do with, with this system. Subsequent operations are automatic and run seamlessly without further intervention. Once the nodes are placed around, and in such a way that most points in the 3D space are in line of sight with each node (to avoid multi-path noise), the system is ready to perform rangings with those targets that obtain a node time slot. In fact, the system operates using a single uwb frequency (about 6.5 GHz), having a 6.81 Mbps transmission data rate. This forces interfering nodes to be 'on air' at different times, according to the well known TDMA principles. A number of problems were addressed and solved to make the system working. Due to the lack of space they will not be comprehensively discussed here,

rather they will be just listed or shortly outlined. In what follows it is assumed that all nodes are connected to a central server, which acts as a monitoring agent as well as the main system coordinator and data collector. Connection of nodes to the server is based on an Ethernet or Wireless LAN, the former being the preferred one as provides higher reliability and speed.

As soon as the nodes are placed around, a sophisticated procedure is started (centralised version, a distributed version is also available), that sets up the node's network and synchronizes all the units. All the procedure's steps run in a couple of seconds having about 200 nodes almost uniformly distributed in the clean room space. The procedure is a significant part of the Nextechs Indoor Positioning Protocol (NIPP, which complies with the 802.15.4-2011 IEEE standard), indeed. Continuous server monitoring and nodes' self monitoring, new neighbours discovery, and other housekeeping activities are carried out in order to keep the nodes' network updated and efficiently working, fault tolerant guaranteed. Self reconfiguration is automatically triggered in case of failures or configuration changes are sensed, and it is as fast as a few seconds. When in operative state, the nodes are ready to do two way rangings with the tracked units, the TARGETS, moving in the surrounds. The targets asynchronously request access to nodes time slots, collisions are automatically managed, and even a back off automatic procedure is implemented when the network hangs-up due to excessive access requests.



Nodes to Targets two way rangings



Nips Target for the Clean Room Application (9 x 5 cm)

IV. PERFORMANCES

When addressing the performances topic, it is important to distinguish static versus dynamic conditions. The Nips system has been designed to support dynamic tracking of large scale setups, where up to thousands of objects are automatically located in small areas. In static conditions objects' positions coordinates are as accurate as with a 3 - 6 cm standard deviation, whilst in dynamic conditions the accuracy falls to a 10 - 20 cm standard deviation, having 4 nodes involved in the rangings (typical node-target distances are in the range of 10 to 20 m). Specific approaches can be adopted to improve accuracies when prior knowledge is embedded in the model (e.g. when it is known the objects' sets of possible paths) or inertial sensors data are available. In fact, the Nips targets embark a solid state accelerometer that is also used to wake up the target when it is moved, and to sense freefall or shocks.

Last, but not least, the Nips has also been designed to report specific telemetries, such as battery status, reed relay status, and the above mentioned accelerometer events.

V. CONCLUSIONS

NIPS is one of the first systems devised to operate on large scale deployments, where many objects of different types need to be tracked in real time or almost so. It is easy to install, to configure, and use. It is also a relatively cheap technology, and it lends itself to many applications, also thanks to the small size of the target circuit to be attached to the objects to be located.

ACKNOWLEDGMENT

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* the DW1000 is a registered trademark of Decawave - Ireland