Real Time Livestock Tracking System Based on UWB Technology

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***Abstract*—A real time animal localization system was developed based on UWB technology. The system consists of a set of fixed receivers (anchors), clock distributor, tags and optionally clock repeaters. Two types of tags were developed: ear tag and collar tag. They differ in size and battery life time. Communication between anchors, clock, repeaters and PC is based on Ethernet. The system requires minimum four anchors for 2D localization and one more for 3D localization. Clocks signal and synchronization signal is distributed with power supply using Ethernet cables to anchors. It is possible to connect up to 10 anchors to the clock distributor. If more anchors are needed clock repeaters are used which can be cascaded to encompass required area. Anchors are placed approximately in distance up to 40 meters depend on obstacles and 3 to 5 meters over maximal altitude expected for tags' location. Developed software calculate position of tags based on time difference of arrival of tags' messages to anchors. Calculated positions of tracking objects and other telemetric data are stored in database and also can be shown in real time on the floor plan. For optimal anchor placement special simulation software was developed. A number of modules for animal health monitoring based on gathering data are under development.**

Keywords—RTLS; UWB; wired synchronization; precision farming;

I. INTRODUCTION

Among many promising technologies applied in real-time location systems (RTLS) ultra wide band communication seems the most appropriate for tracking animals on farms in buildings. It is come due to hard conditions usually met on farms which cause problems with keeping clean optical sensors for example. In recent years a few companies offers commercial systems based on UWB both working based on time difference of arrival and angle of arrival. The main disadvantage of these solutions is cost of devices. Our solutions stand out among them with a lower cost of infrastructure and good precision of localization.

II. INFRASTRUCTURE

The location system consist of one clock distributor, minimum five anchors (receivers in fixed positions) for 3D localization, optionally clock repeaters and tags (see Fig. 1).

Clock distributor is a source of very precision clock signal for receiver circuits in anchors and a source of synchronization signal which is used to set counters in receivers to known state. Each clock distributor has ten outputs so ten anchors can be connected. Clock signal can be distributed to distance over 100 meters. In large systems clock repeaters can be connected to get required structure of the installation. Data with time of arrival and telemetry are sending via Ethernet to data server where position is calculated and stored with other data in database. Designed tags have very flexible software and several parameters can be configured using selected anchors as a beacons or using independent external device. Tag configuration can be changed via radio permanently or locally which means that for some regions tags behave in another way than in others. Number of sent blinks (messages) can be fixed in time or depend on activeness of tracking object what is favorable for battery lifetime.

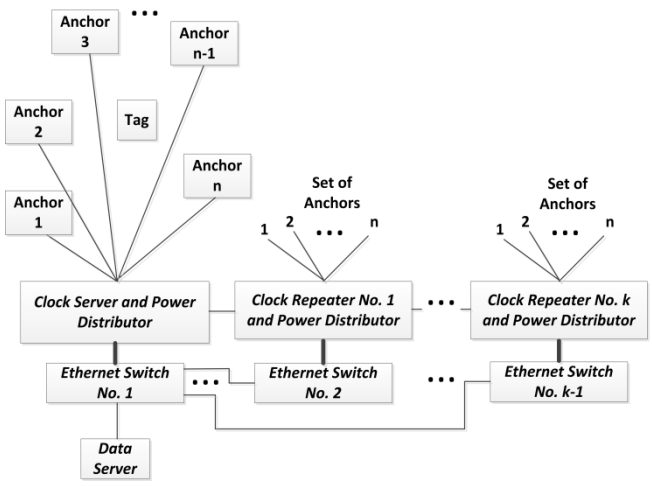

Fig. 1. Real time location system infrastructure.

III. POSITION CALCULATION

The RTLS technique based on Time Difference of Arrival (TDoA) provides an object position determination service by calculation intersection of hyperboloids obtained on the basis of the measured differences in time of radio impulse arrival to individual anchors. Using sets of hyperboloids equations[1], which coefficients were determined based on the relative

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position of anchors and time differences of arrival of radio impulse from tag, it is possible to calculate position of this tag. Position determination can be computed by finding intersection of hyperboloid equations, designated on the base of anchors coordinates and measured by anchors time differences of arrival of radio impulse generated by tag [2,5].

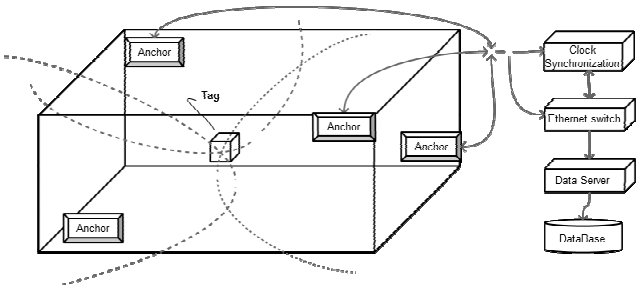

Fig. 2. Real time location system equipment and its possible location in space.

IV. Synchronization and Communication

The process of anchors synchronization in system includes the steps described below (see Fig. 3).

Clock synchronization server, anchors and data server establish connection between each other using local Ethernet network. Next anchors send synchronization request to clock, and clock synchronization server generates clock synchronization pulse for all anchors. Anchors synchronize their internal clocks, according to generated synchronization pulse.

Tags transmit series of radio impulses with data contained unique tag identifier. Anchors receive radio impulses sent by tags and then send Ethernet data packets containing the tag identifier, the timestamp of received radio impulse and other telemetry data to the data server. Server collects data from all anchors and designate time differences of arrival information based on saved timestamps. TDoA of all received messages are used to calculate position of tags using multilateration algorithm and positions are stored in data server database.

V. Optimal Anchors Deployment

The accuracy of the position determination is highly influenced by appropriate location of anchors. Accordingly, it is necessary to provide a method for optimal displacement of set of anchors, which will ensure the least possible error level of determined coordinates of active tags in test area[4]. There is provided a method based on Monte Carlo algorithm, for finding optimal information about precise displacement of anchors in the area of interest, that minimizes possibility of the erroneous designation of a tags coordinates.

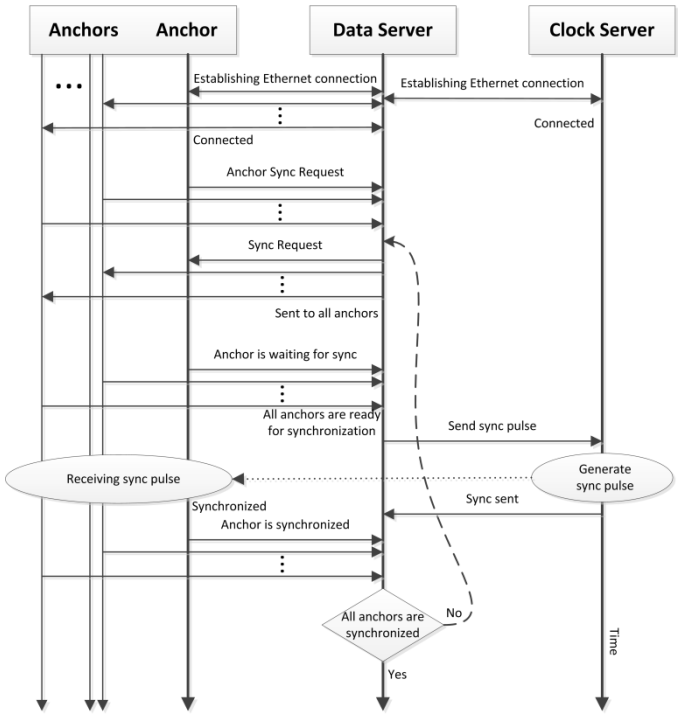

Fig. 3. Real time location system synchronization process .

Monte Carlo method is used for sensitivity and quantitative analysis in the process of design deployment of anchors in the analyzed area. When planning optimal anchors deployment, design must be proved to work properly in all area of interest. Monte Carlo algorithm is used to generate set of possible coordinates of locations in tested area and then the TDoA values statistical error introduced in real system are calculated. Next real locations and those calculated from TDoA data are compared. Anchors dislocation performance (in the sense of fault tolerance) is then evaluated and, if results are not satisfactory, the anchors deployment design goes through an optimization process.

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