Resumen de Tesis Doctoral

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Título de la tesis	Time synchronization in Underwater Acoustic Sensor Networks
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(Mínimo 1 y màximo 4, podéis verlos en http://doctorat.upc.edu/gestion-academica/carpeta-impresos/tesis-matricula-y-deposito/codigos-unesco)

Resumen de la tesis de 4000 caracteres máximo (si se superan los 4000 se cortará automáticamente)

This thesis deals with the development of a time synchronization algorithm for underwater sensor networks. The ease of deployment and maintenance of wireless networks leaded this research to the use of an acoustic communication sensor network to share a common base time between all nodes.

Acoustic signals are well adapted to the underwater medium but experience very challenging impairments such as Doppler, extensive multi-paths and low transmission speed that can nevertheless be corrected at the reception side.

Several acoustic waveforms can be invoked to transmit digital data through the underwater medium, without loss of generality, in this study is considered Orthogonal Frequency- Division Multiplexing (OFDM) communication scheme to exchange data between wireless underwater nodes containing sensor time references. This communication link will be used among others to carry time stamp message required for network synchronization.

Time synchronization is a critical piece of infrastructure of any distributed system. UWSN make extensive use of synchronized time for many services provided by a distributed network. In UWSN, Global Positioning System (GPS) signals are not available and synchronization systems are mostly based on acoustic communication. Owing to high latency of the underwater acoustic transmission channel with respect to cabled or radio network makes the use of conventional synchronization protocols even more challenging underwater.

Many time synchronization algorithms for underwater wireless sensor networks (UWSN) can be found in literature, such as TSHL, D-SYNC, DA-Sync. but only a few of them take into account all the water channel challenges, such as low available bandwidth, long propagation delays and sensor node mobility.

To solve this problem, in this research a further development of the existing time synchronization protocols found in literature is driven. To perform time synchronization we apply Precision Time Protocol (PTP) std. IEEE 1588, which is capable to synchronize two clocks with a precision below hundreds of nanoseconds in a point to point cabled Ethernet Network, and DA-Sync protocol, which is a bidirectional message exchange based method between a master clock and an slave one, and refines its time synchronization parameters by using medium kinematic models.

In cabled synchronization systems, such as PTP, time stamps are acquired in physical layer (PHY) in order to achieve maximum precision, avoiding indeterministic time like Operating System (OS) time slots or medium access protocols. Analogously, it happens in acoustic communication, time stamps are extracted from a large acquisition window, and the improvement of these time stamps is treated in this thesis.

Contrary to cable networks, the low celerity of wave sound makes underwater acoustic communications system very sensitive to Doppler effect, yielding to non-uniform frequency scaling represented by compression or dilatation of the time axis. This frequency scaling can be induced by two factors: motion (sensor mobility, channel variation, etc...) and clock skew receiver between transmitter and receiver. Actually, in order to address this problem, some systems uses expensive inertial sensors for compensating Doppler scaling due to motion and temperature compensated low drift clocks. So in this thesis is evaluated the Doppler scaling caused by motion and skew in order to correct it.

Finally, several tests in the laboratory, test tank, and at sea are performed in order to check the performance of acoustic communication and time synchronization. Results show a correct behavior of hardware and software, and also validate the performance of the time synchronization applied to acoustic UWSN.

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Firma