An Acoustic and Wireless Network Linking an Offshore Seabed Current and Wave Monitoring Station to a Shore Based Receiver

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ABSTRACT


Coastal processes have been monitored for the Tugun desalination plant for over a year by attaching a 1 MHz Sontek Argonaut ADCP and a YSI 6600 CTD to an in-house designed seabed platform with data being downloaded every two weeks by raising the instruments to the surface, manually transferring the data via an interface cable to a laptop computer and re-deploying the system to the seabed. Analysis of the results indicate sporadic internally trapped waves travelling northward along the East Australian coast may be the “cold dirty water” described by local fishermen and whose sediment transport budget impact may be under-estimated by current coastal hydro-dynamic models. Further investigations are underway.

The system being discussed and described in this paper upgrades this labour intensive methodology as it allows for data downloading to be undertaken leaving the instruments in-situ. By including an acoustic modem between the seabed unit and a surface buoy and with the addition of a Campbell Scientific CR1000 and wireless modem link a mesh radio network can be established linking the seabed unit to the shore. Real-time interrogation of the unit can then occur allowing for immediate confirmation of the equipment functioning correctly and for management decisions to be made using current and up to date data.

Whilst the fundamentals of this system are not new, the novel capability is the addition of additional units into the monitoring area which are immediately picked up and added to the mesh network. Utilising this capability, a series of monitoring stations can be daisy chained away from the shore based receiver station allowing for a comprehensive array of sensors covering a wide area. Furthermore, the system is modular in construction and can be utilised for many other coastal applications that require remote sensing and data recording with the added advantage of a real-time display back to a central command node or WWW.

ADDITIONAL INDEX WORDS: Coastal processes, internal waves, desalination, Gold Coast, Australia.
During the survey it became apparent that the ability to retrieve data during the year long monitoring program was often hindered by bad weather and extreme sea states so an Acoustic and Wireless Network system was proposed linking the offshore seabed current and wave monitoring station to a shore based receiver. It also became apparent that the utility of this system would be enhanced if real-time data was transmitted enabling current status time dependent management decisions to be made. A further benefit that has evolved from the system is the ease by which additional systems can be brought into the survey area and be automatically identified by the established network.

This paper describes a data acquisition platform (Figure 1) that utilises an underwater acoustic modem (DSPCOMM, 2009) between the seabed unit and a surface buoy. With the addition of a Campbell Scientific CR1000 running Loggernet, Pakbus software (CAMPBELL SCIENTIFIC, 2009) and wireless modem link (RF INNOVATIONS, 2009) a mesh radio network linking the offshore unit to the shore can be established. This system would provide field data relayed directly back to a shore-based work station where it could be assessed, potentially within a management framework. Furthermore, this system would minimise the costs, risks and impacts of repeated field excursions.

**METHODOLOGY**

**Buoy Design**

Traditionally, metocean buoys have been based on a “doughnut” shape with ballast counter weight. This configuration tends to follow the wave profile thus adversely affecting horizontally reading instruments such as anemometers and vertical reading instruments such as downwards looking acoustic doppler current meters (ADCP’s).

A novel design was manufactured at Griffith University by modifying a traditional Royal Navy survey marker flag (Figure 2) into a metocean spar buoy (Figure 3) that rises and falls with the waves but minimises lateral movement.

**Spar Buoy to Shore Base Wireless Radio Modem Link**

Buoy to shore data transmission is carried out using radio modems (Figure 4). The RF Innovations Piccolo series of radios are 433MHz licence free high speed radio modems capable of interfacing with virtually any RS232 device. By utilising flow control, the Piccolo transparently moves data from end to end at speeds of up to 38.4kbit/s. Depending on the geography and terrain, the Piccolo 433MHz radio is capable of communicating...
reliably up to 5km line of sight. Furthermore, it can perform as a store and forward repeater to extend the range.

A second Piccolo Radio unit is established linked to a shore based laptop. Once the radio link has been established, real-time interrogation of the metocean buoy can occur allowing for immediate confirmation of the equipment functioning correctly.

**Seabed Unit to Spar Buoy via Acoustic Modem Link**

DSPComm, an Australian company has developed an underwater acoustic modem that provides a reliable communications link in adverse underwater environments. By utilising the latest digital signal processing technology up to 3 km range is standard with longer ranges possible. Doppler and severe reverberations effects in the underwater channel are minimised utilising digital spread spectrum communications technology.

By utilising spread spectrum signalling techniques lower signal levels are required, the system is resilient to noise and jamming, unaffected by reverberations and reflections and as pseudo random noise codes are used to modulate the data the signal appears to outside parties as a noise signal making the detection of the signal virtually impossible. Transducer is omni-directional so hence special orientation is not required

**Data Recording, Processing and Mesh Networks**

The ideal wireless sensors networks (Figure 5) must accommodate multi-mode sensors, be location-aware and by utilising multi-hop, mesh networking provide breakthrough performance and cost improvement compared to conventional wired or manual approaches.

By utilising the Campbell Scientific CR1000 measurement and control system, the associated Loggernet software and the PakBus communications protocol these conditions can be met.

A PakBus devise is one that is capable of creating and processing PakBus packets which enable real-time sharing of network communications resources by interleafing the transfer of packets from multiple stations over the same hardware link. There are two levels of Pakbus packets. BMP5 packets handle high-level data logger functions such as clock, program send, data collect and logger to logger functions. Low level PakCtrl packets handle such functions as neighbour discovery and router to router communication.

For two PakBus devises to be neighbours they must first “discover” each other by “hilloing”. Once the hello exchange has been established, the two devises are neighbours.

**Routers**

A router is a PakBus devise that has the capability to receive process, re-address and transmit a packet towards its destination. A router also has the ability to participate in the network routing system.

A network routing system is fundamentally driven by routers learning who their neighbours are and building a neighbours list. Branch routers are an exception in that they only learn the name of a central router but through the central router can access every node in the network.

A leaf node extends from a branch router and requires less memory resources. It is good practise to set as many nodes as possible to be leaf nodes and allow only routers to be beacons.

**Neighbours**

Programming the neighbour to act as a “hello-exchange” enables a recording station to automatically connect to a new recording station entering within the mesh network. Neighbours are confirmed during periods of data transfer and regular software selected verification intervals. Should contact be lost between two recording systems both units will start “hilloing” thus attempting to re-establish neighbour status.

**DISCUSSION**

Field data forms the foundation of environmental research activities. The traditional approach is to undertake detailed water quality and other measurement using sampling and subsequent analysis techniques or where available to use remote sensors and
data loggers. These techniques are limited in usefulness for the development of management actions because the data is generally only relevant for the specific time it was collected; the data acquisition programs are expensive, particularly if long time series is required, and usually the results are not available for some time after the measurements were taken.

The need to deploy sensors ad-hoc, conforming to the natural environment and covering very wide areas is also critical. Remote sensor deployments must deliver reliable communication at low power levels and have the ability to aggregate data and communicate in real time.

Data transfer from field location to processing centre can often be risky. Data transfer between loggers and computers often generate errors with cables and connectors often the weakest link leading to data corruption and equipment malfunction. Regular traversing of dangerous conditions such as surf zones and bar crossing, can lead to injury and adverse weather conditions can create gaps in time series data collection programs.

In order to effectively manage our natural environment and the impacts of development or natural pressures such as climate change, it is increasingly becoming evident that an adaptive management framework is required whereby monitoring, modelling and management action are integrated. In this context, it is imperative that data be obtained and transmitted to a central processing point in real-time. Models which process data for patterns or trends (E.g. DELFT 1992) then provide the most effective way of developing management action in response to negative changes in the state of the environment. The outcomes of this action will be manifested in the data which is continuously obtained, thereby providing new calibration for the models.

**CONCLUSION**

Whilst the fundamentals of this system are not new, the novel capability is the addition of additional units into the monitoring area which are immediately picked up and added to the mesh network. Utilising this capability, a series of monitoring stations can be daisy chained away from the shore based receiver station allowing for a comprehensive array of sensors covering a wide area.

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**REFERENCES**


