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Use of Wireless Networking in a marine environment to control remote equipment from a land based station

Glen S. Merrick
Garry J. Heard

Defence R&D Canada – Atlantic

Technical Memorandum
DRDC Atlantic TM 2005-113
July 2006

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Abstract

The Rapidly Deployable Systems Technology Demonstration Project (RDS/TDP) has used many methods of communicating with the data acquisition processors in deployed sonar systems. A recent requirement to increase the available bandwidth of the communication system has escalated to the use of standard Ethernet technology to transfer data. Discussed in this report is the use Wireless Ethernet technology to communicate with remotely deployed sonar systems.

Résumé

De nombreuses méthodes de communication avec les processeurs d’acquisition de données des systèmes sonar déployés ont été utilisées dans le projet de démonstration de technologies sur les systèmes à déploiement rapide (PDT/RDS). Le besoin récent d’accroître la largeur de bande disponible du système de communication a mené à l’utilisation de la technologie Ethernet standard pour le transfert de données. Dans le présent rapport, on discute de l’utilisation de la technologie Ethernet sans fil pour communiquer avec des systèmes sonar déployés à distance.

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Executive summary

The Rapidly Deployable Systems Technology Demonstration Project (RDS/TDP) requires a method of communicating with deployed sonar systems that has significantly more bandwidth than the currently available systems. The use of a Wireless Ethernet system connected directly to the deployed sonar system during trials ensures that data can be remotely recovered and that there is a more complete control of the system than is normally possible. The ability to retrieve data without having to recover and potentially damage a working sonar array during recovery allows scientists the ability to conduct more comprehensive tests on the deployed sonar system and verify the results in near real-time.

From previous trials where a slower wireless system had been used, the benefits of this wireless Ethernet network are clearly shown. Acoustic data collected from the systems are large data sets. This is due to the number of hydrophones in the array and the sample rates required for the bandwidth of the receiver. The completed files can be several gigabytes in size.

The significance of this method of communications is not limited to the RDS equipment, nor is it limited to communicating with only one piece of equipment at a time. An operator from one location can control a wireless network consisting of several deployed systems. Any remotely deployed equipment that has Ethernet capability has the potential of being connected and having its data relayed back to a base-station as required by the scientific authority. Additionally where an array is deployed in an operational mode, the data could be streamed back to the operator station without having to deploy a costly sub-marine armoured data cable.

In the near future, wireless networking will approach the gigabit mark allowing significantly improved bandwidth and capacity to command and control remotely deployed equipment.

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Sommaire

Le projet de démonstration de technologies sur les systèmes à déploiement rapide (PDT/RDS) a besoin d’une méthode de communication avec les systèmes sonar déployés qui offre une largeur de bande nettement plus grande que celle des systèmes actuels. L’utilisation d’un système Ethernet sans fil connecté directement au système sonar déployé pendant les essais fait en sorte que les données peuvent être récupérées à distance et qu’on peut exercer un plus grand contrôle sur le système qu’il n’est normalement possible de le faire. La capacité d’extraire les données sans avoir à récupérer un réseau sonar opérationnel, avec les risques de dommages que cela comporte, permet aux scientifiques d’effectuer des essais plus complets sur le système sonar déployé et de vérifier les résultats en temps quasi réel.

En tenant compte d’essais précédents dans lesquels on a utilisé un système sans fil moins rapide, on voit clairement les avantages offerts par le réseau Ethernet sans fil. De grands ensembles de données acoustiques ont été recueillis à l’aide des systèmes. Cela s’explique par le nombre d’hydrophones dans le réseau et par les vitesses d’échantillonnage requises pour la largeur de bande du récepteur. Les fichiers de données complets peuvent atteindre une taille de plusieurs gigaoctets.

Le potentiel de cette méthode de communication ne se limite pas aux systèmes à déploiement rapide, et il ne se limite pas non plus à la communication avec un seul composant d’équipement à la fois. Un opérateur peut, à partir d’un endroit, commander un réseau sans fil formé de plusieurs systèmes déployés. Tout équipement déployé à distance compatible avec la technologie Ethernet peut être connecté à une station de base et lui transférer les données qu’il recueille selon les besoins de l’autorité scientifique. De plus, lorsqu’un réseau est déployé dans un mode opérationnel, les données pourraient être transmises en continu vers le poste de l’opérateur sans qu’il soit nécessaire de déployer un coûteux câble sous-marin blindé.

Dans un avenir rapproché, les réseaux sans fil auront presque atteint la marque des gigaoctets, ce qui améliorera de façon significative la largeur de bande et la capacité de commander et de contrôler l’équipement déployé à distance.

Merrick, G., Heard, G. 2005. Utilisation de réseaux sans fil dans un milieu marin pour commander à distance l’équipement à partir d’une station terrestre.
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1. Introduction

The Rapidly Deployable Systems Technology Demonstration Project (RDS/TDP) has employed many methods of communicating with the processors that control data acquisition in deployed sonar systems. Those methods include RS-232, RS-485, Benthos acoustic modems, Freewave wireless modems, and recently TCP/IP over Ethernet. The latest attempts with TCP/IP over Ethernet seem to be the most promising due to the available bandwidth.

All methods of communication tend to have a maximum theoretical transfer rate that is limited by cable/path lengths and other factors. Generally, the communication methods are limited to very slow transfer speeds, usually less than 192 Kpbs. This data rate is sufficient if you are simply controlling the unit and do not want to recover any data files. Acoustic data samples tend to be large files. This is due to the number of hydrophones in the array and the sample rates required for the bandwidth of the receiver. The files can add up to several gigabytes worth of data; therefore, a transmission medium that can sustain a high bandwidth is required. When data needs to be recovered from the unit, the only option is to proceed with a full recovery of the array and controller. The problem with this is that you lose the ability to do timely and detailed testing on the equipment in that particular deployment.

Recently, Ethernet connections have been provided between the controller can on the seafloor and the surface where a laptop has been connected to the cable. An Ethernet connection is established to download the acquired data. Immediate on-site inspection ensures that useable data have been recorded. The problem with this downloading method is that a boat is required to maintain station for an extended period while the data transfer is in progress. This method only works when the weather is calm.

A proposed solution to the high-bandwidth connection with a deployed sensor system is to provide a broadband wireless connection directly to the deployed array controller. This solution entails a wired Ethernet connection from the sea-bottom controller to a surface buoy. The surface buoy contains batteries, a router, a wireless bridge, and an omni-directional antenna. The data is then transmitted to the shore station using 802.11g wireless Ethernet protocols. The shore station has a directional antenna that is pointed towards the area where the surface buoy is deployed, a wireless bridge, a router and the operator station computer. A bridge is a piece of equipment that connects two separate networks together. The bridge also filters network traffic, such that only traffic destined for the remote side of the bridge goes through the bridge.

The wireless network is secure and the data is encrypted to prevent unauthorized access into the network. The wireless network would be a long-range network with the ability to connect from the shore station to the surface buoys over a distance of 1.6km.

Should wireless communication to the arrays be a requirement for future deployments, the use of an 802.11g wireless network using the equipment stated in this document would allow high-speed communication between a shore station and a deployed array collecting test data. The benefits of having a secure high-speed data network that connects the deployed arrays are that the high-speed link allows a quick recovery of data, and provides a better control of the arrays by being able to fully configure the recording capability of the array and the availability of the full command set that is not available through some of the existing RDS communication channels (notably the Benthos modem interface).

In Section 2, a field trial is described in detail that will provide information on the use of 802.11g networks with deployed sonar systems. Full details of the equipment, procedures, and configuration are provided. Section 3 discusses the merits of the experiment and draws comparisons with previous attempts to create a TCP/IP network with a long-distance RF link. Section 4 provides cost estimates of the various system components. Finally, Section 5 presents a summary of the expected benefits of implementing the proposed network solutions.

2. The Proposed Experiment

2.1 Purpose

To determine the following characteristics of the network:

1. Maximum throughput of the network as it relates to the distance from the shore station.

2. Determine the maximum effective distance of the network from the shore station to the equipment in the water.

3. Test the security of the network.

2.2 Equipment

2.2.1 Shore Station:

1 Cisco Aironet 2414S-R Sector Antenna (AIR-ANT2414S-R)
1 Cisco Aironet 1310 Bridge (configured as Root) (AIR-BR1310G-A-K9-R)
1 Cisco Aironet Power Inverter (AIR-PWRINK-BLR2)
1 Cisco 831 Router (CISCO831-K9)
1 Laptop
1 Coax Cable, RG-8 or Aironet 600 Ultra Low Loss Cable with RP-TNC (plug/jack) connector 50m
2 Coax Cable with RP-TNC (plug on one end, jack on the other) connectors 2m
1 Ethernet Cable 3m
Grounding Block for connection between power Inverter and Bridge.
2.5” Diameter Mast to mount Aironet 2414S-R Sector Antenna
Accessories to secure mast to roof or ground
1 Cisco Aironet A/B/g PCMCIA Wireless Card for Laptop - AIR-CB21AG

2.2.2 Buoy:

1 Cisco Aironet 24120 Omni Directional antenna (AIR-ANT24120)
1 Cisco Aironet 1310 Bridge (configured as Non-Root) (AIR-BR1310G-A-K9-R)
1 Cisco Aironet Power Inverter (AIR-PWRINK-BLR2T)
1 Cisco 831 Router (CISCO831-K9)
1 Power supply pigtail (Cisco part number 37-0708-01
2 Coax Cable with TP-TNC connectors 2m
Pressure Vessel
Floatation
Battery Packs

Flasher
Radar Reflector
Ethernet cable
Datel UCP-48/1.5-D48 DC/DC converter 36-75V in, 48V 72W out (Power Injector)
Datel USQ-18/5.6-D48N DC/DC converter 36-75V in, 18V, 5.6A out
Fuses, 1A max
Fuses, 3A max
1 UCARA04 Can with/out array attached.
DC Block – Minicircuits BLK-18
Bulkhead – custom – RF passthrough
Bulkhead – 4 pin - Ignition
Bulkhead – 6 pin - External Power
Bulkhead - 8 pin x 2 – Ethernet connections
Pigtail – 4 pin – pins 1&2 shorted and pins 3&4 shorted for Ignition
Pigtail – 6 pin unshorted to cover External Power connection on deployment
Pigtail – 8 pin x 2 – unshorted to cover Ethernet connections on deployment

2.3 Procedure

This section describes the how the equipment will be configured, and how the experiment will be conducted to establish a broadband TCP/IP network over an RF link between a shore-based operator station and a deployed sonar system.

2.3.1 Configuration of Equipment

The Cisco equipment must be serviced to ensure that the latest firmware and software has been installed. A contractor should have at least a Cisco Certified Network Professional or preferably a Cisco Certified Security Professional designation to perform the task of configuring the software and hardware of the Cisco equipment to ensure that the network is properly secured.

The system will be configured as per the connection diagram in Figure 1. Shore Station will be used in the future as the point from which data is recovered and commands are sent to the buoys.

2.3.1.1 Shore Station : Physical Hardware Setup:

Referring to Figure 1, the shore station (labelled Remote Building in Figure 1) consists of two computers with Ethernet connections in each. Both computers are connected into the Cisco 831 Router. The first computer is used to monitor network traffic and the Ethernet card is configured to be in promiscuous mode. When in promiscuous mode the Ethernet adaptor tells the Ethernet Router it is connected to that it wants to see all traffic on the network.

Data about the network will be gathered for later study. The second computer is used to communicate to the buoy. The router is then connected via Ethernet cable to the Cisco Aironet Power Inverter. The power inverter is connected to the Aironet 1310 Bridge via 2 RG-8 coax cables with TP-TNC connectors. A ground block must be installed around the two RG-8 cables into earth ground. The bridge is finally connected via the same RG-8 Cable to the Aironet 2414S-R Sector Antenna. The antenna has a 90° beamwidth providing a significant coverage area and after installation there should be no requirement to move the antenna.

A mast for the antenna must be raised and secured against high winds. The mast must also be placed in a position where there are no obstructions that would block the view of the antenna when it has been installed.

2.3.1.2 Cisco 1310 Bridge:

The Cisco 1310 Bridge must be configured to ensure that it is the root bridge. The root bridge is the master bridge to which all others connect. The bridge must be secured in such a manner that no other bridges other than the accepted ones can connect to the network.

2.3.1.3 Cisco 831 Router Configuration:

Access the router using the following http connection, http://10.10.10.1.

All nodes will be set with static IP addresses, so that the Array Nodes can be easily identified. This means that DHCP needs to be turned off, and the IP addresses used, placed in the routing table as being assigned.

Hardware encryption must be enabled to ensure that the data is encrypted as it is being transferred between the bridges.

2.3.2 Buoy

2.3.2.1 Physical Hardware Setup:

The buoy is a stand-alone floating station connected to the deployed sonar system. All power will be provided via batteries and this will limit the lifespan of the device. Since this is floating on the surface of the water, the buoy must be waterproofed. This means that the buoy should be constructed from a Schedule 80 PVC pipe with 12” nominal outside diameter. A PVC bottom end cap will be permanently attached to the body.

The bottom end cap will have an eyebolt installed so the support cable between the array and the buoy can be connected to it. Additionally there will be an eight-pin electrical bulkhead installed on the bottom for the Ethernet connection between the buoy and the array.

The lid of the can will be made from PVC and held down with fasteners. There will be an O-ring groove around the inside to prevent water from seeping into the can.

The top lid of the buoy will contain four bulkhead connectors: one 8-pin, one 6-pin, one 4-pin, and one custom connector. The 8-pin connector will be an Ethernet connection for testing and configuration as necessary without opening the buoy. The 6-pin connector will provide external power so that internal batteries will not be depleted when the unit is sealed and additional testing is required. A 4-pin connector will act as an ignition switch for the unit. The custom bulkhead will consist of a short RG-8 cable with a TP-TNC connector on both ends. This will connect the 1310 Bridge to the Aironet 24120 Omni Directional antenna. The antenna will be mounted on a two-meter high mast that will bring the antenna high enough to be above the wave action during storms. The antenna mast will also be used to mount a radar reflector and a night time light beacon.

The grounding block that is required will be connected through a Minicircuits DC Block to an isolated ground plane installed on the lid of the buoy can. The 8-pin connectors on the lid and bottom of the buoy will have Category 6 Ethernet cable soldered to the connector, and the other end of the cable will be terminated with a standard RJ-45 Ethernet jack. Both of these jacks will connect to the Cisco 831 router.

Sufficient floatation, in the form of Kisbee rings, will be required to ensure that the unit is always providing a surface expression. These will be fastened together and then mounted to the buoy.

2.3.2.2 Cisco 1310 Bridge:

The Cisco 1310 Bridge will be configured the same as the bridge at the shore station, except that the buoy bridge will be configured as a non-root bridge. A non-root bridge is a remote station that communicates directly to the root bridge. The bridge must be secured in such a manner that no other bridges other than the accepted ones can connect to the network.

2.3.2.3 *Cisco 831 Router Configuration:*

These routers will be configured identically to the shore station.

2.3.3 Power Requirements:

In Figure 2 a schematic of the electrical system is shown. Battery Power from Bridge + is connected in series and passed though a diode to Pin 1 of the external power connector. The same is done for the Router + connection except that is it connected to pin 3. What this accomplishes is the ability to power the buoy on the shore without using the internal batteries. In order to accomplish this, an external DC power source is set to 75V and connected to the appropriate terminals on the Surface Power connector. The ignition plug is then connected. The 75V will over ride the power supplied via the batteries.

The power requirements of the Router and Bridge are as follows:

The Cisco 831 router requires 18V DC to operate with a maximum power consumption of 18W. The Cisco Aironet Power Inverter requires 48V DC, maximum current of 3A and provides up to 15W of power to the Cisco 1310 bridge over the Ethernet connection.

A Datel USQ-18/5.6-D48N DC/DC converter will be used to output the voltage from the battery packs to the Cisco 831 Router. The converter has an input voltage range of 36-75V and has an output of 18V, 5.6A. The Power Inverter will receive its power from a Datel UCP-48/1.5-D48 DC/DC converter. This will take an input voltage range of 36-75V in, and provide 48V 72W out.

The battery pack will be composed of six forty-eight-cell layers. Each layer has four batteries composed of twelve D size cells, which will provide 18V. The four legs in the layer will be wired in series to provide a total output voltage of 72V. The Cisco 831 Router will be powered from a Datel USQ-18/5.6-D48N DC/DC converter and it will receive power from two layers of batteries wired in parallel to extend the deployment life of the system. The Power Inverter will be powered from another Datel UCP-48/1.5-D48 DC/DC converter and it will be powered from four layers wired in parallel to extend deployment life as well. In total there will be six layers of forty-eight batteries. Figure 3 shows the arrangement of the four battery legs per layer. Each layer will be encapsulated in a polystyrene molded shell to prevent shorting of the batteries.

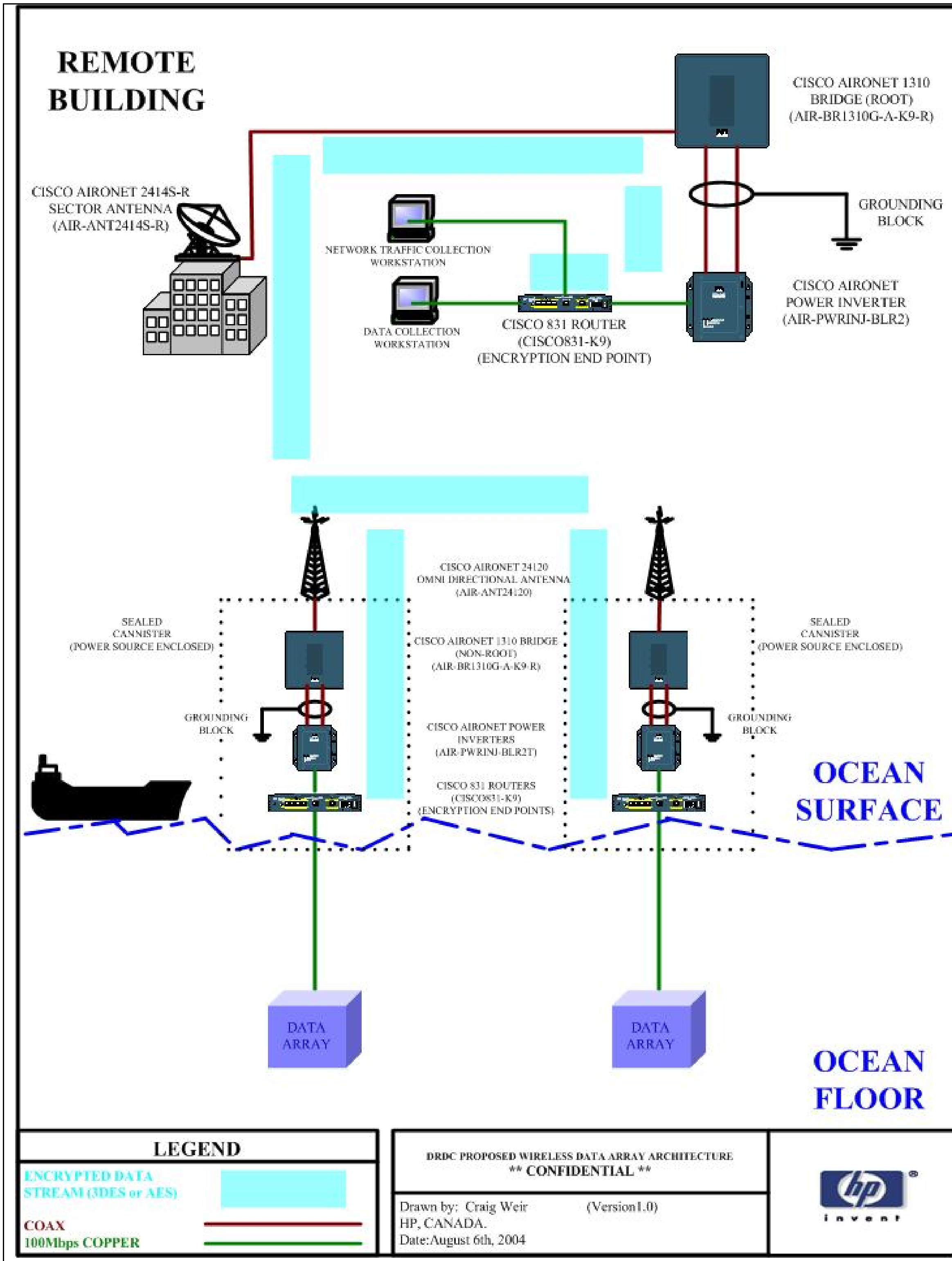

Figure 1: Wireless Data Array Architecture

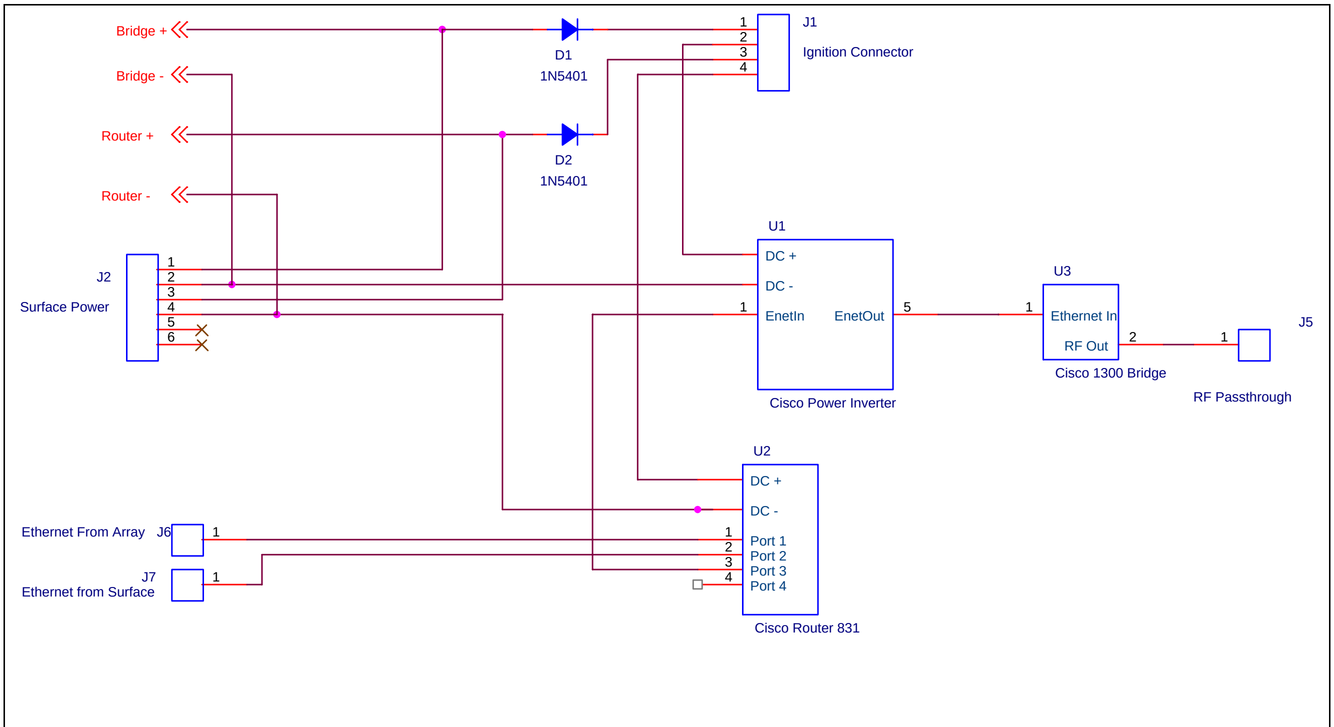

Figure 2:Schematic Overview of Buoy

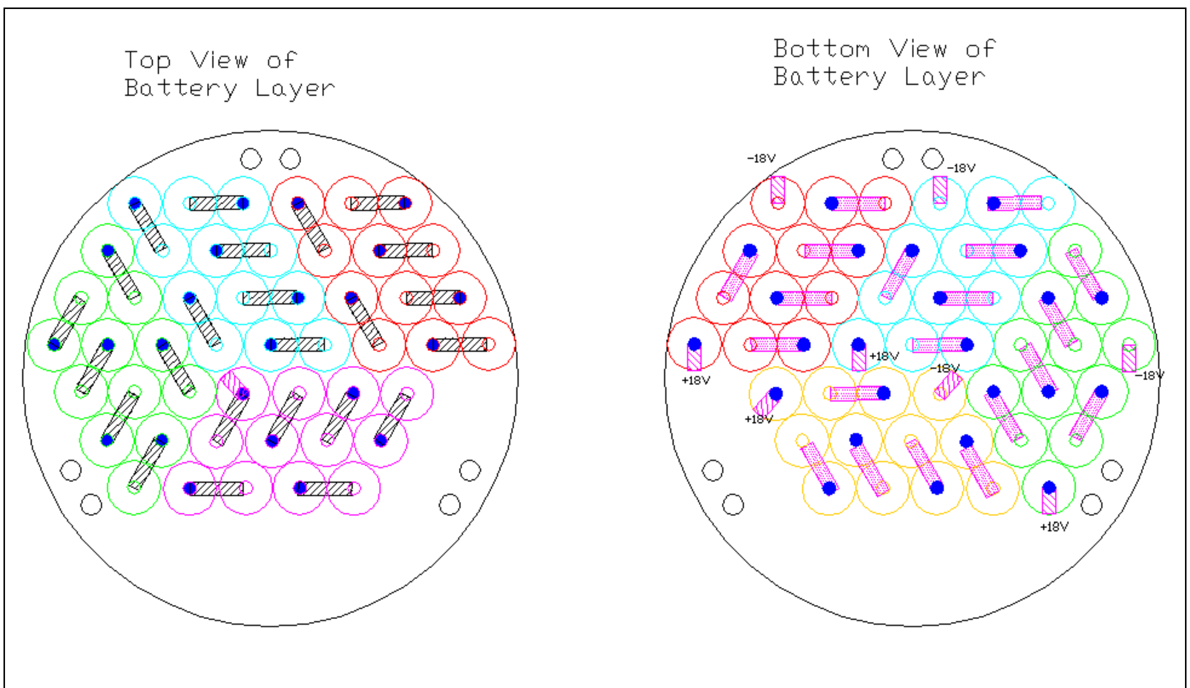

Figure 3: Top and Bottom view of the Battery Layer

2.3.4 Packaging Configuration of Buoy

The dimensions of the equipment to be placed in the buoy are as follows:

Bridge: 8.00 in. x 8.10 in. H 2.62 in. / 20.32 cm W x 20.57 cm H 6.66 cm
Power Injector: 5.4 in. x 2.1 in. x 1.3 in. / 13.7 cm x 5.3 cm x 3.3 cm
Router: 2.0 x 9.7 x 8.5 in. (51 x 246 x 216 mm)

The largest length of the equipment is 8 inches or 20cm, so the closest sizes for schedule pipe is 8", 10" and 12". The other issue is that the diameter of the pipe directly effects the configuration of the battery pack. The larger the diameter the pipe the more batteries can be used per layer, making the total package height lower. The best battery configuration can be made with a 12" schedule 80 PVC pipe. The 12" pipe provides the required space to place four twelve-cell legs per battery layer. The larger diameter pipe also provides additional buoyancy in the air spaces not used. The overall internal length of the pipe needs to be 36". This is generated from the following: the height of the equipment being 15" high when it is housed in an equipment bay. The height of the battery pack is 15.5". On the top and the bottom of the inside of the buoy, 2" of clearance is required at each end to ensure that the connectors have clearance for the wires attached to them.

2.3.5 Displacement and Buoyancy

In order to ensure that the buoy actually floats on the surface and will not sink; we need to calculate the displacement of the buoy. The first calculation needed is the volume of the buoy.

Volume = $\prod * r^2 * h$ where r = 6 and h = 36

Volume = $\prod * 36 * 36$

Volume = 4072 cubic inches /(1728cubic Inches/cubic foot)

Volume = 2.36 cubic feet

The calculation for displacement is:

Displacement = Volume * Mass of water

Displacement = 2.36 cubic feet * 64Lbs/cubic foot

Displacement = 151Lbs

This means that the volume of water the buoy displaces is equal to 151Lbs of water. The last calculation needed is the mass of the entire buoy. This can be approximated using the following numbers:

1 D Cell has a mass of 140g or 0.3087lb. With 288 batteries in the total pack, the total mass of the batteries is 89Lbs.

The equipment's mass is 5Lbs

The buoy, two lids and connectors weigh approximately 25lbs

The Antenna mast mass is approximately 5lbs

The total estimated mass of a complete buoy would be 125Lbs, which means that we have an estimated 25lbs of positive buoyancy. The 25Lbs of positive buoyancy ensures that the buoy will not sink below the surface of the water, but the current buoyancy does not mean that the buoy will remain above the water during a storm. To ensure that the buoy remains above the water at all times an additional 80lbs of buoyancy should be added. This added buoyancy will take the form of an external flotation collar. The flotation collar will be fitted to the outside of the buoy in such a manner to ensure the stability of the buoy in water. Stability of the buoy comes from the difference in the centre of buoyancy minus the centre of mass. This is needed as there is an external antenna and we want to ensure that the buoy remains as vertical as possible.

2.3.6 Test Procedures

After the equipment has been successfully configured, a trial deployment must take place. The UCARA4 canister and array, Category 6 communication cable and the buoy canister are then moved onto a small vessel. Testing will consist of two experiments. The first experiment will determine the maximum distance possible using the wireless connection and the consequent data rates available at each distance. The second experiment will be a full deployment of a UCARA4 system with data collection and transmission.

2.3.6.1 Experiment 1 – Maximum distance of connection

The buoy can is set upright and secured in the aft corner of the vessel and powered on. The UCARA4 canister is secured to the deck, connected to the buoy via the Category 6 communications cable and powered on. Local system tests ensure that both units are functioning properly. The vessel then approaches the shore station antenna as close as possible and proceeds to move away from the shore station at intervals of 500m. At each 500m distance the vessel keeps station to the best of its ability while data is transmitted and received via FTP to the UCARA4 can from the shore station.

While this data transfer is ongoing, a packet sniffer and a traffic analyzer are used to determine the throughput of the connection. This is repeated until the signal strength is degraded to a point where data transfer via FTP can no longer be accomplished successfully. The information gathered from this experiment will determine how far we can successfully have equipment deployed from shore without having repeater buoys in place.

A second method to determine the throughput of the system is to use a software tool called Qcheck from Ixia. This software is installed on both the shore station and a laptop on board the small boat. The laptop is connected to one of the Ethernet connections on the buoy and the utility is directed to communicate with the shore station. Qcheck will return the throughput and the response time of the connection.

2.3.6.2 Experiment 2 – Deployment and data collection

The vessel then moves to a point that is in line of sight with the shore station antenna and that is agreeable for the deployment of the UCARA4 canister and its array. Once UCARA4 is deployed, the buoy is attached to the UCARA4 canister via the Category 6 communication cable. Data recorded by the UCARA4 canister can then be transferred from the canister on the bottom to the shore station, and the throughput can be measured. Experiments to determine how well the Hardware and the array can be controlled through the wireless connection will also be completed. Success will be determined when command and control of the UCARA4 canister is accomplished and data is recovered from the UCARA4 canister remotely via the wireless network.

3. Discussion

The reason for looking at a wireless solution came from the requirement to recover sample test data after Array Element Localization (AEL). The reason was to ensure that the AEL data were good and the gain stage levels of the hydrophones were properly set. If the recorded levels were not high enough, the gains on the hydrophone had to be reprogrammed and additional testing accomplished with the new gain levels. After having to recover the array once to access the data, it was quickly realized that a better method of data recovery was required without disturbing a deployed array. The first method tried was simply bringing an Ethernet cable to the surface from the array; however, the requirement to station-keep on site as data was downloaded from the array for extended periods was not a viable option.

The next step was the use of the Wi-Lan Hopper to test the application of high-speed data transfer. It was demonstrated that from a line-of-site situation where the shore antenna was 1.4km away from the Hopper buoy, we were able to successfully communicate between a computer and the array via high-speed wireless Ethernet. Previously the fastest wireless method had been via the Freewave modems at a maximum speed of 19.2Kbps.

The Hopper allowed an average download speed of 100 Kbps via FTP. The Hopper unit we have can still be used; however it is no longer manufactured. This means that any expansion of the system requires sourcing a new method of communication. The use of an 802.11g wireless Ethernet network gives a theoretical throughput of 54Mbps. In reality, the throughput is expected to be closer to 10Mbps, approximately one-hundred times faster than the Hopper system.

Deployment lifetimes will be limited by the available battery capacity. The proposed batteries will allow approximately four days of continuous operation and is a reasonable compromise between endurance and size.

The cable that carries the Ethernet from the deployed canister to the surface buoy is a Category 6 Ethernet cable that are gel filled and jacketed with UV resistant polyethylene, designed for direct burial. The individual pairs of the cable are separated from each other with a plastic form that looks like two Y’s attached together at the tail. This Category-6 cable provides the bandwidth necessary to allow an Ethernet connection from one hundred and twenty five meters depth to the surface. There are still issues with this cable, such as the varying capacitance as the cable sweeps through the water, which will vary the throughput rate. The ideal situation would be to have a fiber link between the array and the buoy.

4. Cost Estimates

This section describes the estimated cost of the total system of networking equipment and also breaks down the cost into the individual components of the Shore Station and each buoy.

4.1.1 Shore Station

The shore station's cost is described below in Table 1. Included in the cost is the consulting fee for configuration of the Cisco Bridge and Router. This is a non-repeating cost, as the equipment configuration can be copied directly into new equipment as it is acquired.

Table 1: Shore Station Costs

PART #	DESCRIPTION	**QTY**	**UNIT PRICE**	**EXTD PRICE**
CISCO831-K9	Cisco 831 Ethernet Router	1	$ 602.24	$ 602.24
AIR-BR1310G-A-K9-R	Aironet 1310 Outdoor AP/BR w/RP-TNC Connectors, FCC Config	1	$ 1,205.76	$ 1,205.76
AIR-ANT2414S-R	2.4 GHz, 14 dBi Sector Antenna w/RP-TNC Connector	1	$ 1,112.96	$ 1,112.96
AIR-PWRINJ-BLR2=	AIRONET 1300 POWER INJECTOR - LR2	1	$ 259.20	$ 259.20
HP-SA1-ONSITE	Onsite Network Security Consulting / per day - Craig Weir	1	$ 1,550.00	$ 1,550.00
	RG-8 Cable, 100 feet	1	$ 100.00	$ 100.00
	Antenna Mast	1	$ 400.00	$ 400.00
HP-SA1-ONSITE	Onsite Network Security Consulting / per day - Craig Weir	1	$ 1,550.00	$ 1,550.00
	Total Shore Station Cost:			**$ 6,780.16**

4.1.2 Communications Buoy

The communications buoy cost is described in the following spreadsheet. This is the cost to manufacture one node only. The cost of batteries is re-occurring as they are depleted, and will need replenishing after every deployment.

Table 2: Communications Buoy Costs

Communications Node				
PART #	**DESCRIPTION**	**QTY**	**UNIT PRICE**	**EXTD PRICE**
CISCO831-K9	Cisco 831 Ethernet Router	1	$ 602.24	$ 602.24
AIR-BR1310G-A-K9-R	Aironet 1310 Outdoor AP/BR w/RP-TNC Connectors, FCC Config	1	$ 1,205.76	$ 1,205.76
AIR-ANT24120	2.4 GHz, 12 dBi Omni Mast Mt. Antenna w/RP-TNC Connector	1	$ 645.12	$ 645.12
AIR-PWRINJ-BLR2T=	AIRONET 1300 POWER INJECTOR - LR2T (DC power option)	1	$ 259.20	$ 259.20
	PVC Pipe Schedule 80 12" Diameter, Length 48"	1	$ 60.00	$ 60.00
	PVC Bottom end Cap, machined 1" thickness, Diameter 12" with 1 threaded bulkhead hole and 1 threaded hole for eyebolt	1	$ 50.00	$ 50.00
	PVC Top cap, with O-Ring Grooves, 1" thickness, Diameter TBD with 4 threaded bulkhead holes.	1	$ 50.00	$ 50.00
	Male Bulkhead 8 pin	1	$ 120.00	$ 120.00
	Female Bulkhead 2 pin	1	$ 120.00	$ 120.00
	Female Bulkhead 4 pin	1	$ 120.00	$ 120.00
	Male Plug 2 pin Shorted	1	$ 35.00	$ 35.00
	Male Dummy Plug 2 pin	1	$ 35.00	$ 35.00
	Male Dummy Plug 4 pin	1	$ 35.00	$ 35.00
	Male Dummy Plug 8 pin	1	$ 35.00	$ 35.00
	Pigtail, 4 pin with 10 foot pigtail	1	$ 75.00	$ 75.00
	Male Locking Caps	10	$ 15.00	$ 150.00
	Radar Reflector	1	$ 200.00	$ 200.00
	Energizer Industrial LR20 or Panasonic Industrial D Batteries	422	$ 1.00	$ 422.00
	Night-Flasher	1	$ 40.00	$ 40.00
	RG-8 Cable, 2 feet	4	$ 25.00	$ 100.00
	Total Cost for Communications Node			**$ 4,359.32**

5. Conclusion and Summary

Should wireless communication to the arrays be a requirement for future deployments, the use of an 802.11g wireless network using the equipment stated in this document would allow high-speed communication between a shore station and a deployed array collecting test data. The current Hopper based solution is past end-of-life therefore, an up to date solution is required. The benefits of having a secure high-speed data network that connects the deployed arrays allows not only the speedy recovery of data, but it allows better control of the arrays, through the ability to quickly configure the recording capability of the array and the availability of the full command set that is not available through the Benthos interface. Though the solution looks costly, the cost for one node and the shore station is per node is only ninety-five hundred dollars, with additional nodes costing forty-five hundred dollars each. It is not necessary to hire the contractors to configure new units when purchased as the configurations can be copied from the existing units and copied to the new units. The major re-occurring cost is replacing the batteries after depletion. A solution to this problem would be to use batteries that are rechargeable and solar panels.

6. References

1. Cisco Systems Inc. – http://www.cisco.com

2. Wi-LAN – http://www.wi-lan.com

List of symbols/abbreviations/acronyms/initialisms

802.11g	Wireless Ethernet protocols using the 2.4 gigahertz bandwidth with a transmission rate up to 54Mbps
DHCP	Dynamic Host Configuration Protocol
DND	Department of National Defence
DRDC	Defence Research and Development Canada
IP	Internet Protocol
Kbps	Kilobits per second. Equal to 1024 bits per second
Mpbs	Megabits per second. Equal to 1048576 bits per second
UCARA	Ultra-light Canadian Acoustic Research Array
RDS	Rapidly Deployable Systems
RP-TNC	Reverse Polarity-Threaded Neill Concelman, a type of radio-frequency connector.
TCP/IP	Transmission Control Protocol / Internet Protocol
TDP	Technology Demonstration Project

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The Rapidly Deployable Systems Technology Demonstration Project (RDS/TDP) has used many methods of communicating with the data acquisition processors in deployed sonar systems. A recent requirement to increase the available bandwidth of the communication system has escalated to the use of standard Ethernet technology to transfer data. Discussed in this report is the use Wireless Ethernet technology to communicate with remotely deployed sonar systems.

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