An Integrated Coastal Wireless Network: 2004 End-of-Year Interim Report

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LONG-TERM GOALS

The goal of this study is to define a wireless network architecture that can be deployed to enable contiguous coastal area network coverage for scientific, commercial, and homeland security (e.g. Coast Guard) applications within the United States Exclusive Economic Zone (EEZ), in a manner that is flexible, manageable, and affordable. As described in Reference 1, we intend to determine the architectural requirements of such a system, delineate suitable technologies that will achieve such a vision, and provide a plan to demonstrate the concept.

OBJECTIVES

Initially, user requirements (i.e. functional requirements) for the United States Coastal Area Network (U-SCAN) will be determined. These requirements will encompass all three intended domains of use: scientific, commercial, and homeland security, as depicted in Figure 1.

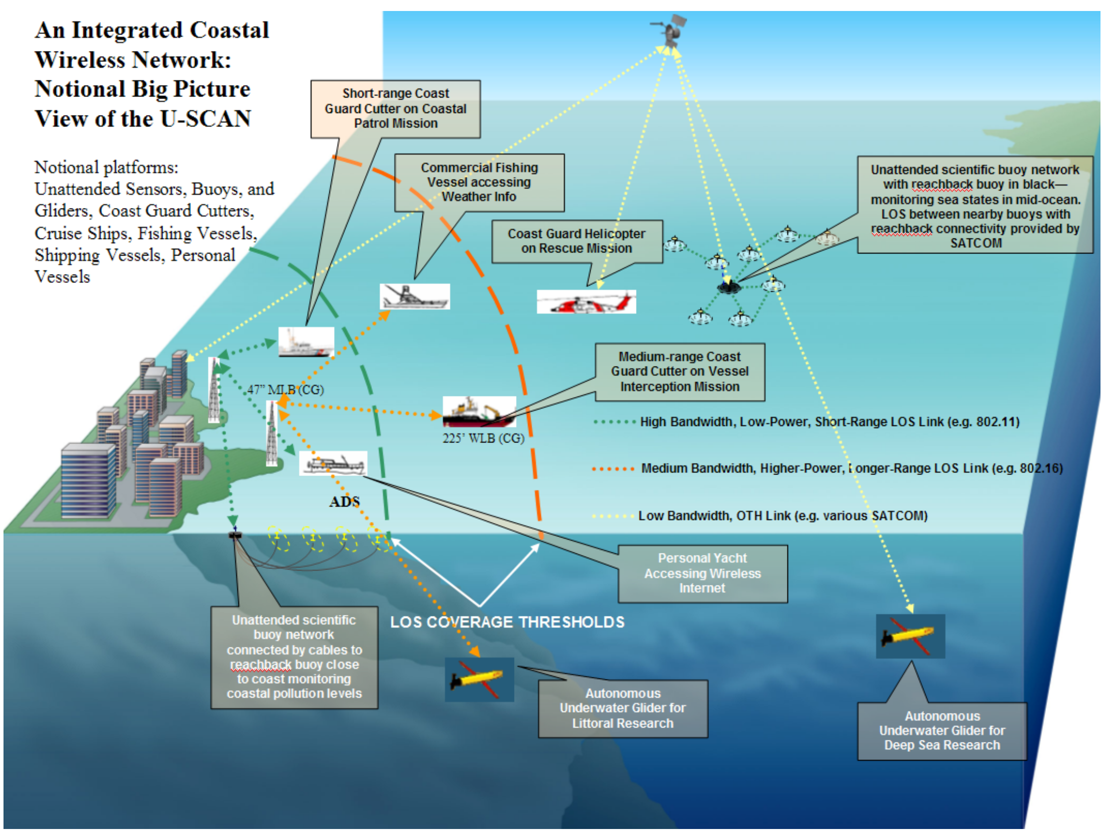

Figure 1 A Vision of the Eventual Multi-purpose U-SCAN

A technology candidate catalog will then be delineated that summarizes the capabilities and drawbacks of envisioned communications systems, focusing on technologies commercially available within the timeframe of interest. An appropriate subset of technology candidates will be chosen for detailed architectural consideration based upon an initial analysis of all technology candidates and an assessment of how well they meet the determined user requirements. A secondary down-selection will result in a select set of technology candidates deemed most promising. These candidates and their associated power requirements, cost estimates, and architecture integration issues will be described in detail in the final architecture description along with some notional scenarios. A technology demonstration and transition plan will result from the architecture definition.

APPROACH AND WORK PLAN

The high-level work plan for the first year of this project is presented in Figure 2. Initially, high-level functional requirements will be determined, including: 1) approximate user applications along with corresponding data packages and performance requirements, and 2) notional operational scenarios for the U-SCAN. Requirements of the scientific community will be determined by Drs. Scott Glenn and Oscar Schofield of Rutgers University, who maintain a coastal network for Rutgers University's oceanographic research. Potential Coast Guard requirements will be determined by JHU/APL through coordination with appropriate Coast Guard representatives. Perceived commercial requirements will be determined by the composite team. The JHU/APL portion of the team will then translate these functional user requirements into technical requirements. These two requirement sets are isolated from one another in order to prevent network technology constraints from introducing bias into the requirements of the user.

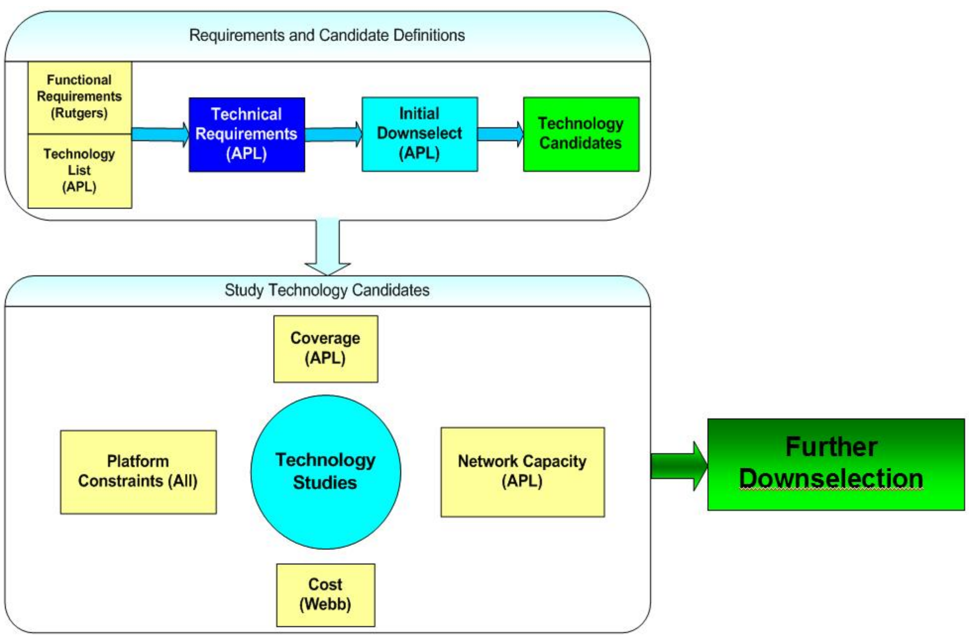

Figure 2 Year One Project Technical Approach Overview

Available WLAN and over-the-horizon (OTH) communications technologies will be assessed for their overall applicability against the requirements by William Kasch, Jack Burbank, and Robert Nichols of JHU/APL. This assessment will begin with an initial cataloging and high-level characterization of commercially-available technologies (represented as the 'Technology List' of Figure 1). These technologies will then be judged against user requirements and a corresponding down-selection will occur. Remaining candidate technologies will further undergo a more rigorous evaluation.

Performance studies will be conducted to determine the viability of those remaining technology candidates to be combined in an integrated architecture. Studies focusing on coverage, platform constraints, and network capacity will be performed by the JHU/APL team members. The results of these studies will be used to perform another down-selection. The remaining 'best-of-breed' technology candidates will constitute the candidate set at the end of year one, and will undergo a second set of technical studies during year 2, illustrated in Figure 3. A cost study will be performed by Clayton Jones of Webb Research, whom has conceived and built a variety of oceanic scientific platforms including those used by Rutgers University.

Architecture integration studies will be performed by all participants in the study. Here, four areas of interest for study were identified: 1) routing and Quality-of-Service (QoS), 2) network management, 3) security, and 4) interference. The routing and QoS study will focus on methods of classification and efficient routing of packets through the envisioned variable U-SCAN network topology. The network management study will attempt to identify network management techniques and approaches that effectively improve ease-of-use and promote automation to minimize maintenance cost and network complexity. The security study will attempt to identify suitable security policies, models, and mechanisms, along with assessing the impacts of such security mechanisms on U-SCAN performance. It is expected that in an environment where commercial, scientific, and homeland security users operate concurrently, many different types of security will be required to meet user needs. Both the network management and security studies will focus on commercial best practices and commercially-deemed viable solutions. Finally, an interference study will be conducted to determine the performance impacts of potential U-SCAN technologies have on neighboring communications systems, and vice-versa, in order to ensure effective coexistence of technologies and adherence to US and/or International radio frequency (RF) regulations.

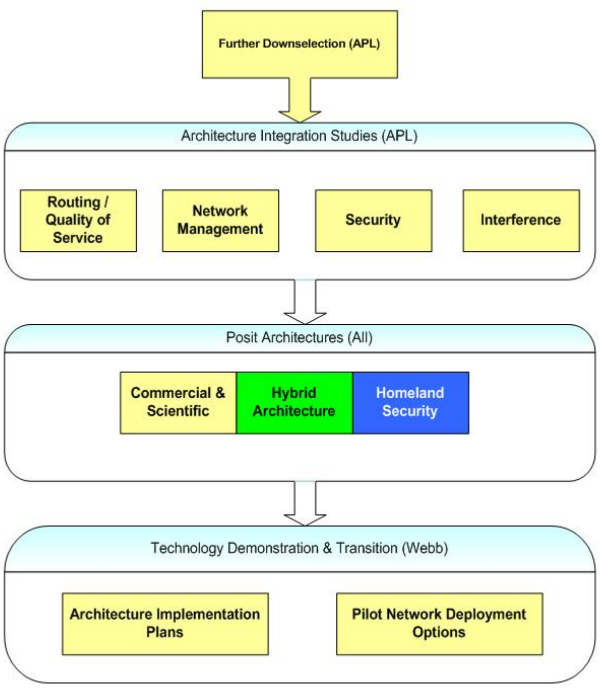

Figure 3 Year Two Project Technical Approach Overview

Finally, technology demonstration concepts will be conceived by Webb Research that aim to identify and address implementation issues, identify technology transition strategies, and provide risk mitigation strategies.

WORK COMPLETED

This project is currently mid-way through Year 1. However, the team has completed several tasks to date. First, high-level functional requirements have been derived for three types of users: homeland security, commercial, and scientific (Reference 2). Specifically, a listing of notional platform types for each of these three categories has been delineated, along with a few operational scenarios where multiple platform types from several categories may need to utilize the U-SCAN simultaneously. Second, a technology catalog has been produced that lists current and expected future technologies that could be used in a U-SCAN architecture (Reference 3). The technology catalog contains specific information on each technology, including its expected range, power requirements, platform constraints, cost, and preliminary estimates on suitability for integration into the U-SCAN architecture. The technologies considered in this catalog are: IEEE 802.11, IEEE 802.16, IEEE 802.15, Freewave, ETSI HIPERLAN, ETSI HIPERPAN, ETSI HIPERMAN, Ultra Wide-band (UWB), Iridium, Globalstar, Inmarsat, and Argos. Additionally, higher layer technology candidates have been identified and discussed, including Internet Protocol (IP), various IP routing technologies (e.g. Ad-hoc On-Demand Distance Vector (AODV)), and various transport technologies (e.g. Transmission Control Protocol (TCP)). Third, a preliminary coverage study has been conducted to determine what platforms (ocean-based, ground-based, and satellite) are suitable for providing coverage for the U-SCAN architecture. The study delineated the possible platform types as well as the benefits and drawbacks for each (Reference 4). Definitions of coverage based on bit error rate (BER), latency, and packet loss were also delineated to provide a more precise definition of coverage (Reference 5).

RESULTS

To date, preliminary results from synthesis of the coverage study, functional requirements, and technology catalog suggest that the U-SCAN architecture will need to support multiple radio types (both line of sight (LOS]) and OTH) to provide adequate coverage to the large number of platforms expected to utilize the network—a “one size fits all” solution is not expected to be sufficient given the wide variety of platforms and applications. Additionally, studies into the definitions of coverage have suggested that sufficient coverage based on BER and latency will vary across both user platform and application. Furthermore, performance-based coverage as defined in Reference 5 is a function of the protocol choices at every layer of the International Standard for Organization (ISO) communications reference model. Thus, a sufficient U-SCAN architecture solution will need to consider the entire stack of the protocol stack.

IMPACT AND APPLICATIONS

National Security

An effective U-SCAN architecture could provide high-speed network access to Coast Guard vessels within the EEZ coverage area. Such a network would prove invaluable to Coast Guard professionals who may need to exchange near-real-time imagery, video, and voice traffic to enable more effective coastal surveillance and foreign vessel interception and/or inspection. Furthermore, U-SCAN backhaul connections into other homeland security agencies could enable more effective information sharing between the Coast Guard and such agencies for an overall improved level of homeland security.

Economic Development

Commercial vessels that may have access to an Internet best-effort-type network provided by the U-SCAN may improve bottom lines to their respective companies because they could connect directly to their corporate networks at high speed while in or near ports of entry. Connection to the corporate network enables passengers of the commercial vessels to remain in contact with their company, improving corporate efficiency. Cruise ships that provide high-speed Internet access to their passengers may charge a fee for such a service and could further improve profit margins. Likewise, personal vessels that are outfitted with U-SCAN equipment could be charged fees for such access that could be used to maintain and improve the U-SCAN network. All these possibilities may provide additional jobs related to maintenance and development, and release more corporate capital investment because of improved efficiency.

Quality of Life

Quality of life is expected to improve dramatically for commercial and personal users who may be able to access the near-real-time Internet. Improved efficiency for corporations results in more time available for employees to enjoy other aspects of life. Furthermore, scientific experiments that utilize the U-SCAN may provide insight into weather phenomena that may improve the ability to predict and warn terrestrial areas of impending weather, thus reducing risk to life and land.

Science Education and Communication

The U-SCAN is expected to be an integral part of scientific monitoring and oceanography. By providing the network infrastructure to cover the entire EEZ of the U.S. coast, various scientific sensors and vessels could be deployed to monitor ocean activity and enable many possibilities otherwise unavailable today for scientific experimentation and data collection. Scientific experiments could provide insight into ocean behavior during various natural phenomena including hurricanes, tsunamis, and earthquakes, and has great potential to benefit society through inherent improved data collection capabilities.

RELATED PROJECTS

There are other projects relating to the objective of this project; the most significantly related projects are outlined below with an emphasis on their communications approach. This listing is not exhaustive as there are many small initiatives to extend the use of wireless technology.

- NEPTUNE: The North-East Pacific Time-series Undersea Networked Experiments (NEPTUNE) project is to design an observatory infrastructure for the Pacific Northwest and is a partnership of the University of Washington, University of Victoria and Woods Hole Oceanographic Institution. The system's fiber optic cabling provides both power and communications distributed over 1000 km. Due to the capabilities of fiber optics, the system can deliver large data rates of 10 Gbps and network directly to the Internet. This is a fundamental difference from the U-SCAN project, which primarily focuses on developing a wireless communications architecture.

- MARS and VENUS: The Monterey Accelerated Research System (MARS) and the Victoria Experimental Network Under the Sea (VENUS) are initiatives to link oceanographic instruments with cables, similar to the NEPTUNE project described above.

- VeriLAN Broadband Wireless: This is part of an initiative in the Oregon area to provide high-speed internet to residents on the coastal areas where these capabilities are lacking. In 2003, VeriLAN announced the deployment of a beta test infrastructure of about 100 square miles using the 802.16 system. Estimates of data rates are in the 24 Mbps range. This system utilizes a primary technology of the U-SCAN project (802.16). However, it is focused on land-based users, and relies on the stability of fixed sites to use directional antennas. In contrast, the U-SCAN project aims to create an infrastructure extending further into the ocean area and will need to support platforms without inherent stability. There are many commercial ventures similar to this (e.g., Coastal Broadband in GA, Midcoast Internet Solutions in ME). However, those ventures do not aim to converge a user base as diverse as the envisioned U-SCAN user base.

- High Performance Wireless Research and Education Network (HPWREN): This is an NSF-sponsored initiative to create a wide-area wireless network in three southern CA counties for a variety of uses. It is a multi-institutional initiative of UC San Diego and includes the San Diego Supercomputer Center and the Scripps Institution of Oceanography. HPWREN has supported oceanography applications and demonstrated a link to San Clemente Island at a range of 72 miles. It has been used to support shallow water deployment of data acquisition systems studying waves and erosion using IEEE 802.11b WLAN technology. It has also been supporting scientific instruments out to a range of about 30 km for the California Clean Beaches Initiative.

- LOOKING: The Laboratory for the Ocean Observatory Knowledge Integration Grid (LOOKING) is sponsored by NSF and is a collaboration of the University of Washington, UCSD and others to develop and information infrastructure in the west coast of the US, Mexico and Canada. The project deals with not only communications but sensors, web services and other aspects of an information infrastructure. The project funding announcement was made in September 2004 and limited details of the communications architecture are known. It does intend to use wireless communications (e.g., satellite) based on some preliminary information sheets on the project.

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