Revolutionizing the **Water** World: Cyber-Aquatic Systems
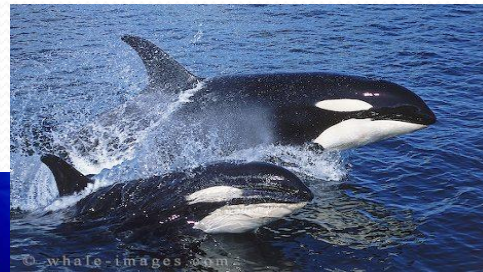
Jun-Hong (June) Cui

UnderWater Sensor Network (UWSN) Lab
http://uwsn.engr.uconn.edu

School of Engineering, University of Connecticut

Potential Applications

Applications & Requirements

- A wide range of applications
  - **Scientific:** (biological, chemical, physical) oceanography, deep sea archaeology …
  - **Environmental:** pollution detection, disaster recovery, climate change, …
  - **Commercial:** oil/gas field monitoring, fishery, treasure discovery …
  - **Defense/HS:** Navy, costal guard, harbor protection, port control …
    - …
- Desired properties
  - **Unmanned** underwater <u>exploration</u>
  - **Localized and precise** <u>data acquisition</u> for better knowledge
  - **Wireless** underwater networking for motion agility/flexibility
  - **Scalable** to 10's, 100's of nodes for bigger spatial coverage
  - **Real-time & interactive** user query and system response

The Ideal Technique:

Smart Ocean Technology (SOT)
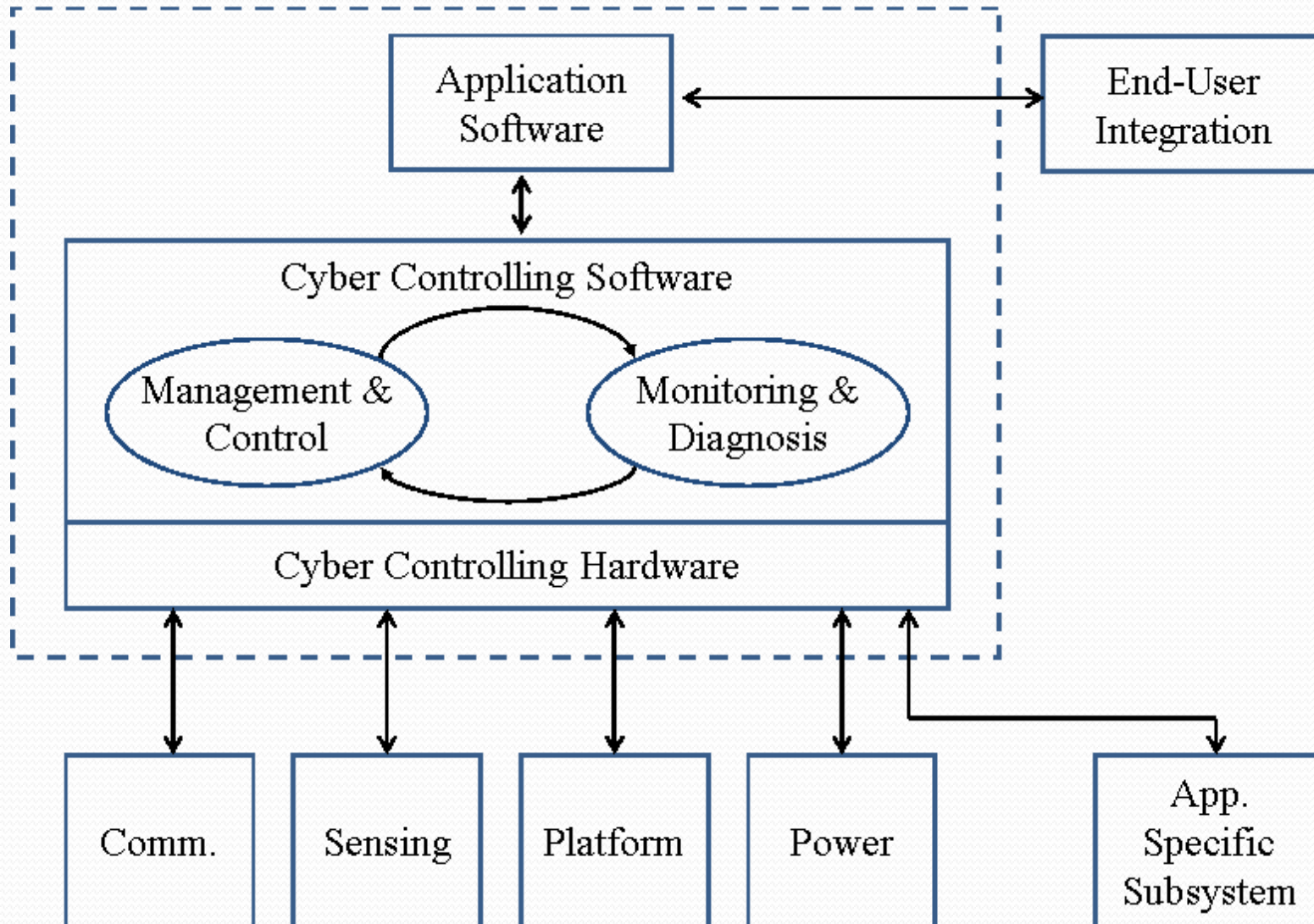*aka*
Distributed Cyber Aquatic System (DiCAS)
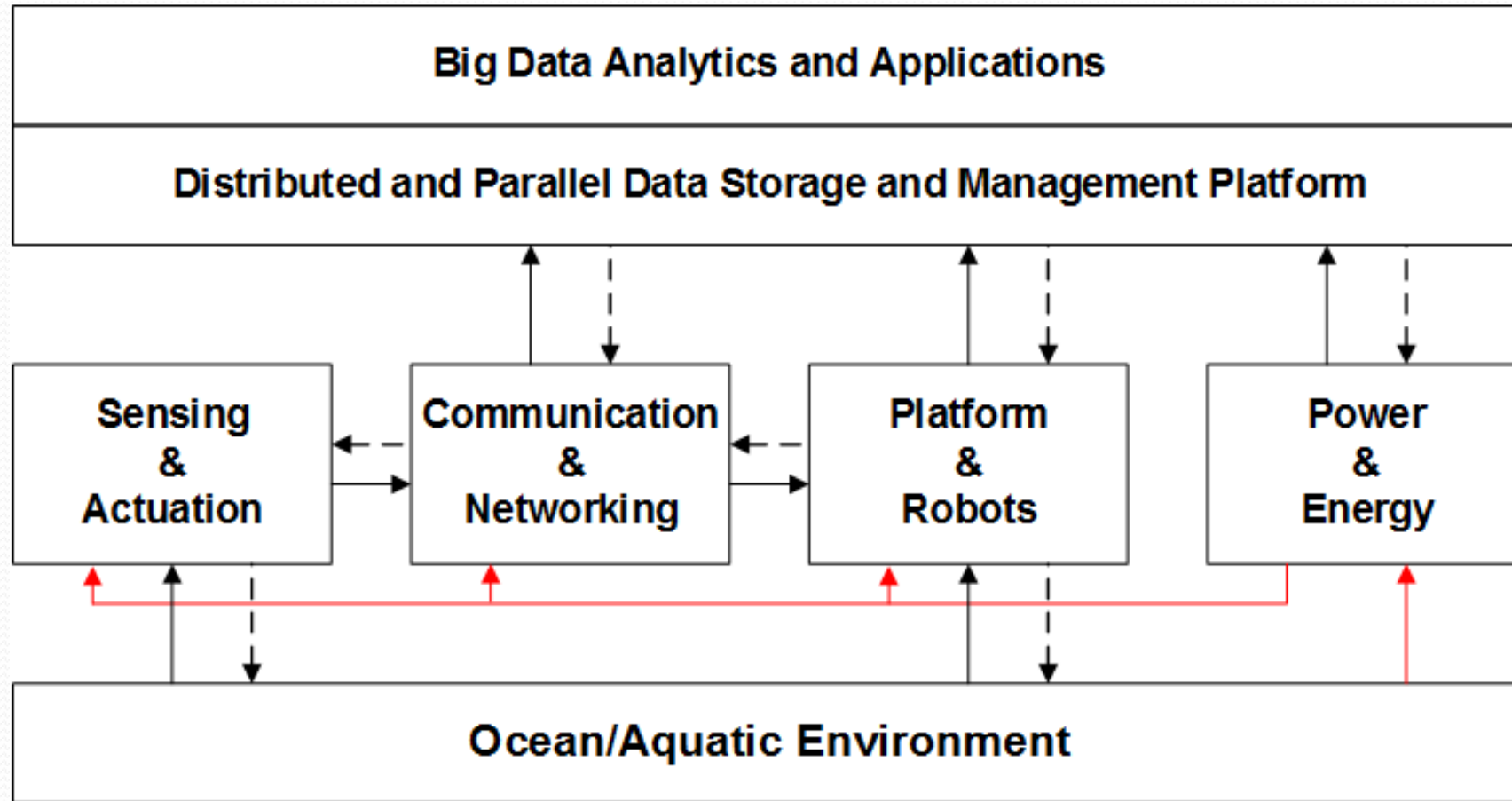*aka*
Underwater Wireless Networked Sensing
aka
Underwater Sensor Networks (UWSNs)

System Architecture (2009)

System Architecture (2014)

Underwater Communication

- Acoustic is most practical and viable among optical, EM, etc.
- Unique characteristics of acoustic channels
  - Low available bandwidth
  - Long propagation delay
  - High error probability
  - High T/S dynamics
- Harsh networking environments
  - Passive or active node mobility
- **New research at every level of the protocol suite is demanded !!!**
  - Reliable, robust, energy efficient underwater comm. & networking

State-of-Art Underwater Acoustics
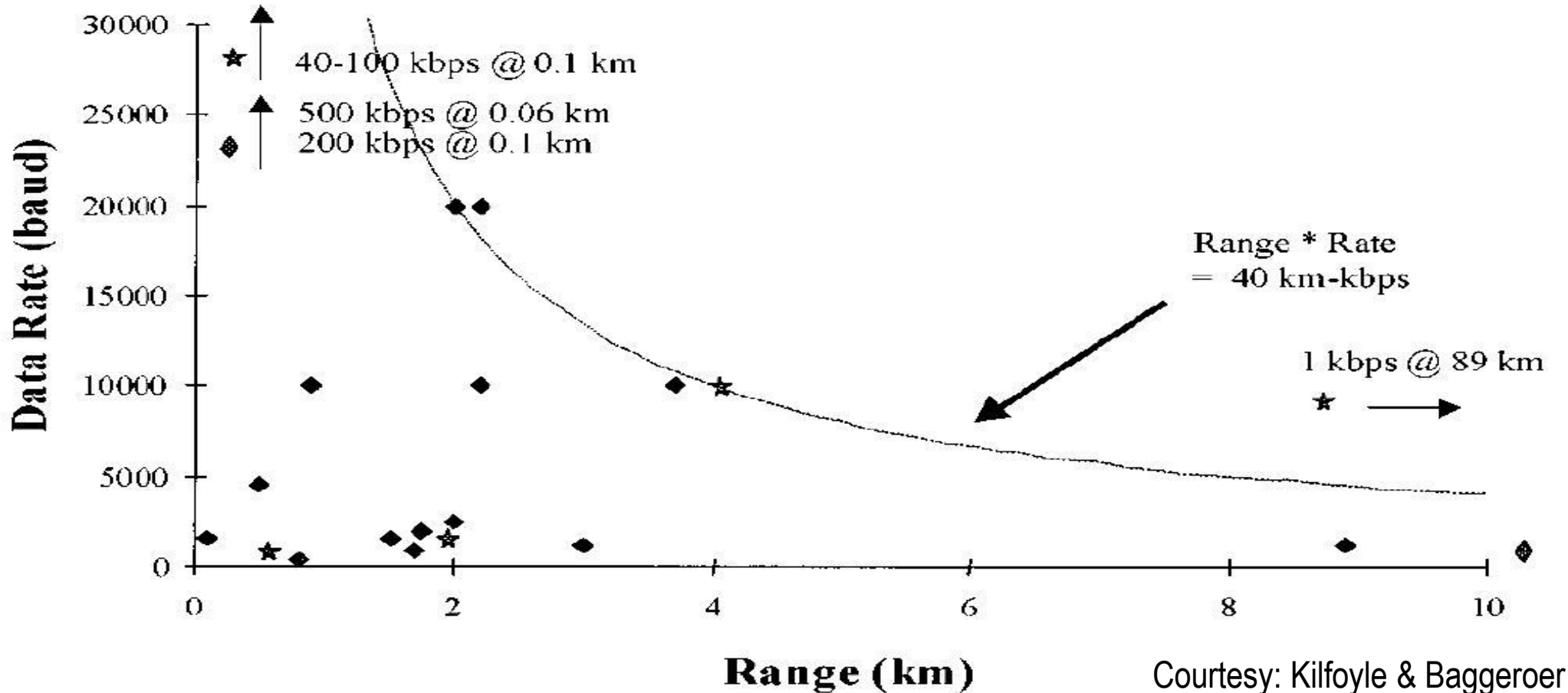

Courtesy: Kilfoyle & Baggeroer

Reported by	Modulation Method	Bandwidth	Bandwidth Carrier	Data Rate	Range
Kaya&Yauchi,Oceans'89	16QAM	125kHz	1000kHz	500kbps	60m
Jones et al.,Oceans'97	DPSK	10kHz	50kHz	20kbps	1km
Capellano et al.,Oceans'97	BPSK	0.2kHz	7kHz	0.2kbps	50km

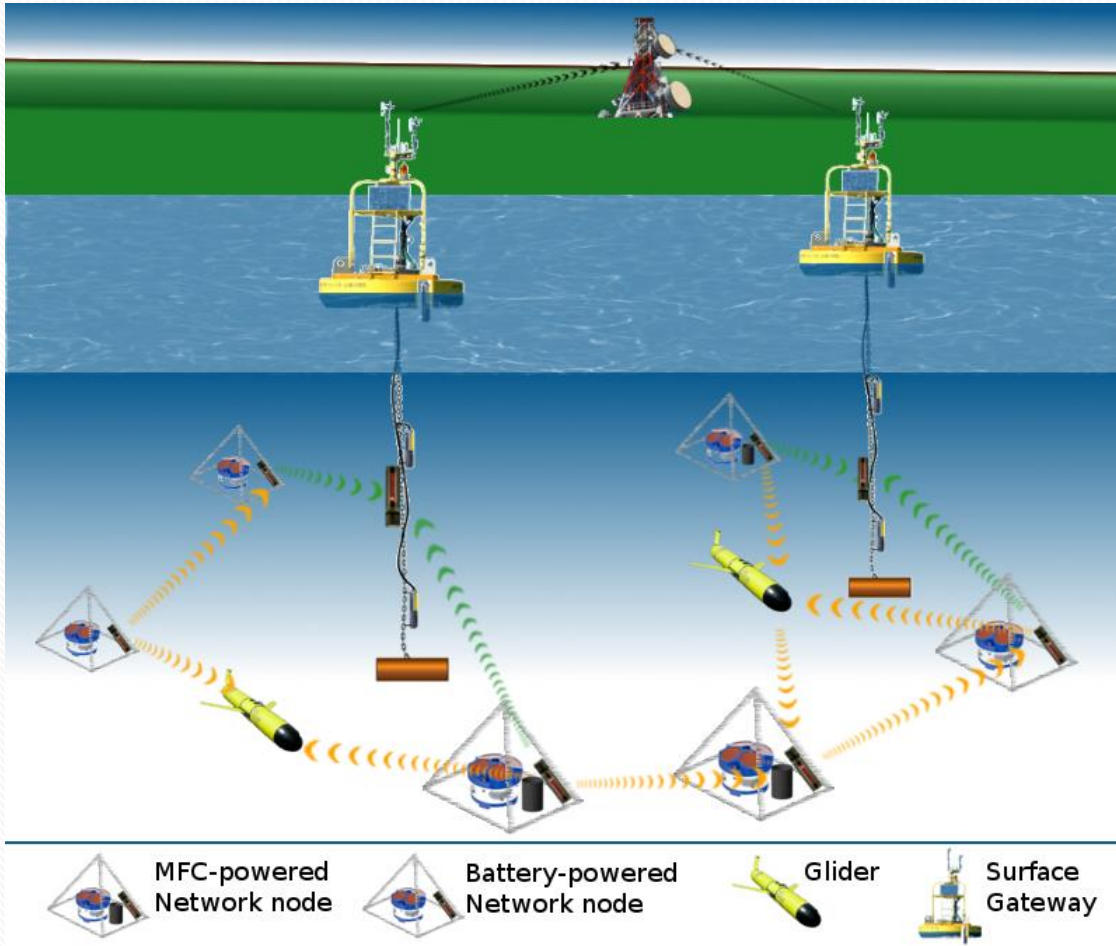# OFDM Modem Development at UConn

- Left: SIMO 1×8 or MIMO up to 8×8
- Right: Modem prototype with housing

Networking with OFDM Modems
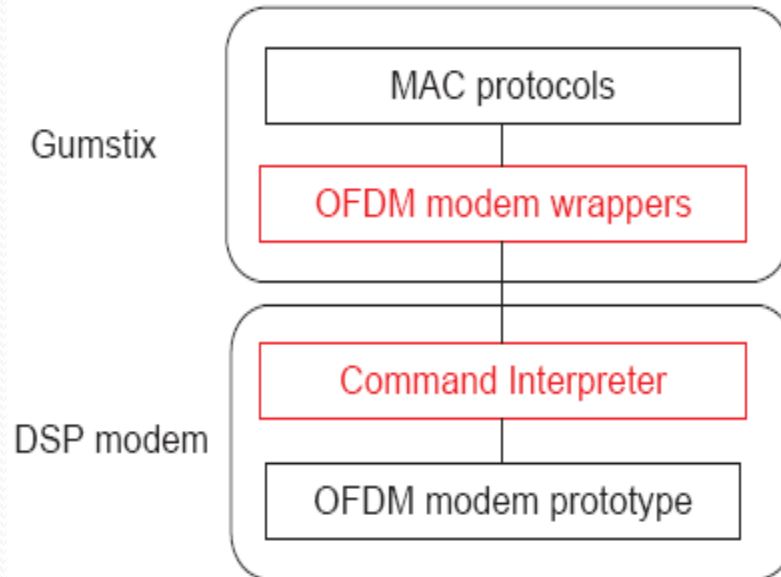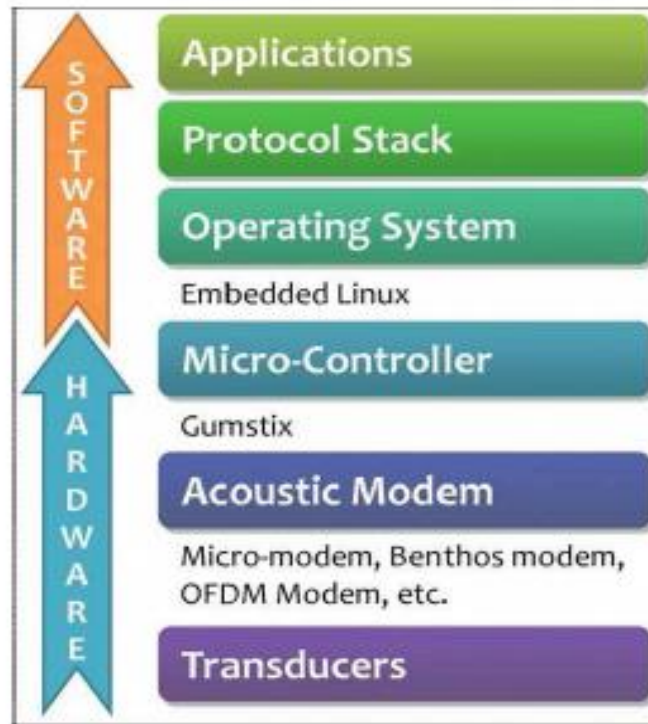
- Connect protocols with OFDM modem prototypes

Ocean-TUNE: A Community Testbed

- Supported by NSF CRI
  - UConn (lead), UW, UCLA, TAMU
  - **$2,635,000 for 3 years**
- Sea Testbed with 4 sites
  - Long Island Sound, Hood Canal, Santa Monica Bay, Galveston Bay
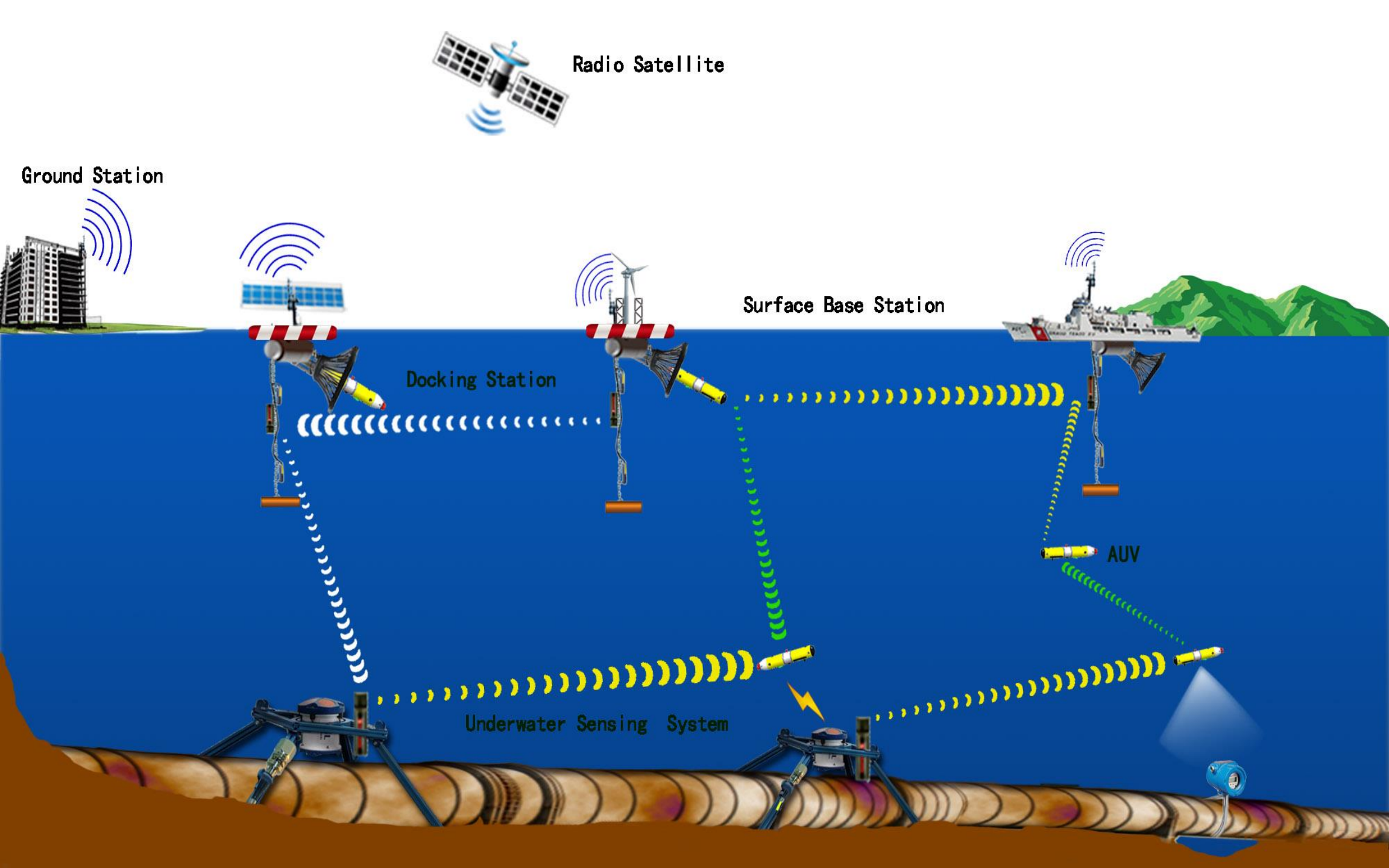- URL: **http://oceantune.org/**

Ocean-TUNE: A Community Testbed (2)

Site	Location	Surface Nodes	Bottom Nodes	Mobile Nodes	Reconf. Modems
UConn	Long Island Sound	3	5	2 Slocum Gliders	2
UW	Hood Canal	2	2	1 Seaglider	2
UCLA	Santa Monica Bay	1	2	1 Drogue	-
TAMU	Galveston Bay	2	1	-	2

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NSF I/UCRC on Smart Ocean Technology

In 2013, collaborating with University of Washington, launched the **VERY FIRST** NSF I/UCRC (Industry/University Cooperative Research Center) for **Smart Ocean Technology**. (http://smartoceantechnology.org).

NSF I/UCRC on Smart Ocean Technology

Radio Satellite

Ground Station

Surface Base Station

Docking Station

AUV

Underwater Sensing System

Thank You!