# Proposal for joint experiments at sea with NURC in October 2012

## Background information

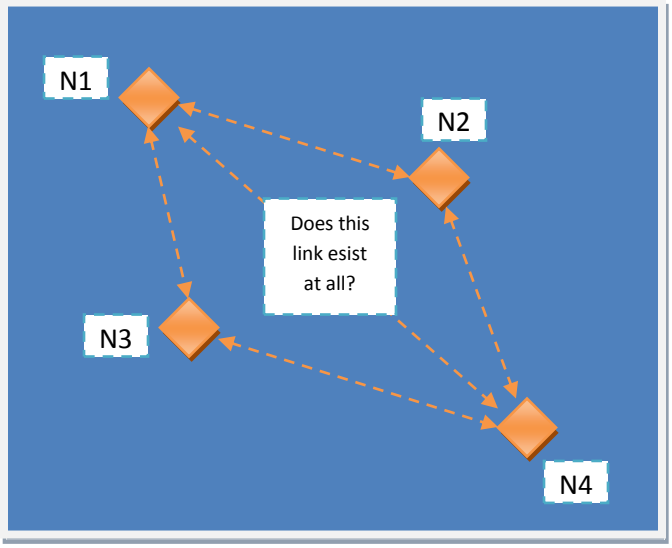
In Padova, we are currently designing some network protocols for underwater mobile networks. A brief list of the protocols and their specifications is as follows

- **Underwater Selective Repeat (USR)** this is basically a selective repeat ARQ protocol that coordinates the transmitter and receiver in time. In more detail, the transmitter sends Data packets and waits for a given time period between subsequent t packets; the receiver knows the timing of the transmitter and sends acknowledgement (ACK) packets so that they arrive at the transmitter when it is listening. The protocol is effective because the channel propagation delay, underwater, is sufficiently large to accommodate more than one packet transmission within one round-trip time (RTT). Some parameters of the protocol can be tuned: for example, setting a higher number of packets to be transmitted within one RTT makes the transmission process more efficient, but also more prone to interference in a multiuser network.
- **UW-Polling** is a protocol to coordinate the upload of data from a field of static sensors (possibly sparsely deployed) to an AUV that patrols the network. The protocol is based on three subsequent phases: (i) trigger, (ii) probe, (iii) poll; TRIGGER packets are periodically sent by the AUV for neighbor discovery purposes; if any sensors receive the TRIGGER, they reply with a PROBE message, which contains any information that can be useful for the AUV to establish a polling sequence (e.g., timestamp of latest data packet generated, position, amount of time the contact with the AUV is expected to last, receiver-side SNR etc.); after PROBE messages have been received, the AUV computes a polling sequence and sends POLL messages in unicast to the nodes, in order to trigger the transmission of data. Such transmission is currently carried out without any form of error control; by the end of October it will be performed using USR.
- **UW-DTN** is a protocol to exchange data between mobile assets in a store-and-forward fashion. The protocol has been designed for a specific scenario, whereby some AUVs are deployed in a quite large area. As “external” mobiles enter this area, one of the available AUVs sets an intercepting course, and follows some mobile assets (e.g., for inspection or tracking of their movement trajectory). As the area to be patrolled is large, the AUVs will meet only occasionally. At this time, they opportunistically exploit the contact to transfer data about the asset they are currently following; also, they may take this chance to transfer data that was obtained during previous contacts. Occasionally, one AUV may get in touch with a control center (a sort of sink node) and transfer as much data as possible to it.
  UW-DTN requires a 4-way handshake to set up a link upon contact between two AUVs (called A and B in the following). Both A and B periodically send BEACON messages for neighbor discovery: say that B receives the BEACON of A; at this point, B transmits an INFO_PACKET, containing a summary of the data in its own buffer (e.g., most recent data available for every asset being followed in the area); after

receiving the INFO_PACKET from B, A also transmits its own INFO_PACKET: this time, the packet contains a list of B's packets that A wants to receive (the details are a bit different, but this description should suffice for now) ; at this point, B sends another INFO_PACKET to A to also declare what packets it wants to receive from A, and immediately thereafter it starts transmitting packets using USR. After B's share of the contact duration has been completed, A can transmit its own packets to B. The share of time allotted to A and B is determined based on an estimation of the contact time, on the amount of data to transmit, and on fairness criteria (it is better to balance the transfer so that the packets contain information about all assets, rather than transmitting a lot of information about a single asset).

With the protocols above, we may carry out the following experiments.

## General information about the bottom-mounted network




**All nodes are equipped with mid-frequency EvoLogics modems**

**Further assets available** (based on my own understanding from the discussion on Monday February 27th, 2012)

- 2 AUVs
- 1 or 2 rubberboats
- Further Evologics modems to be used, e.g., by AUVs or rubberboats

**Environment**: close to the Palmaria island.

## Experiment 1

*UW-DTN in operation.*

We assume to have at least two mobiles (AUVs or rubberboats) that patrol a given area. One of the fixed bottom nodes (e.g., N4) is assumed to be the sink, hence the final destination of the packets generated by the mobiles. The mobiles patrol the area, and generate data packets at fixed intervals (e.g., containing their current position, or a timestamp, any data that can be ordered is ok). When they get in contact (i.e., they can set up a link according to UW-DTN's specs) they transfer data. We want to measure how fast this data reaches the sink, or in other words how many data packets reach the sink and ad what epoch in time with respect to the ideal case (a packet is known at the sink as soon as it is generated by a mobile node).

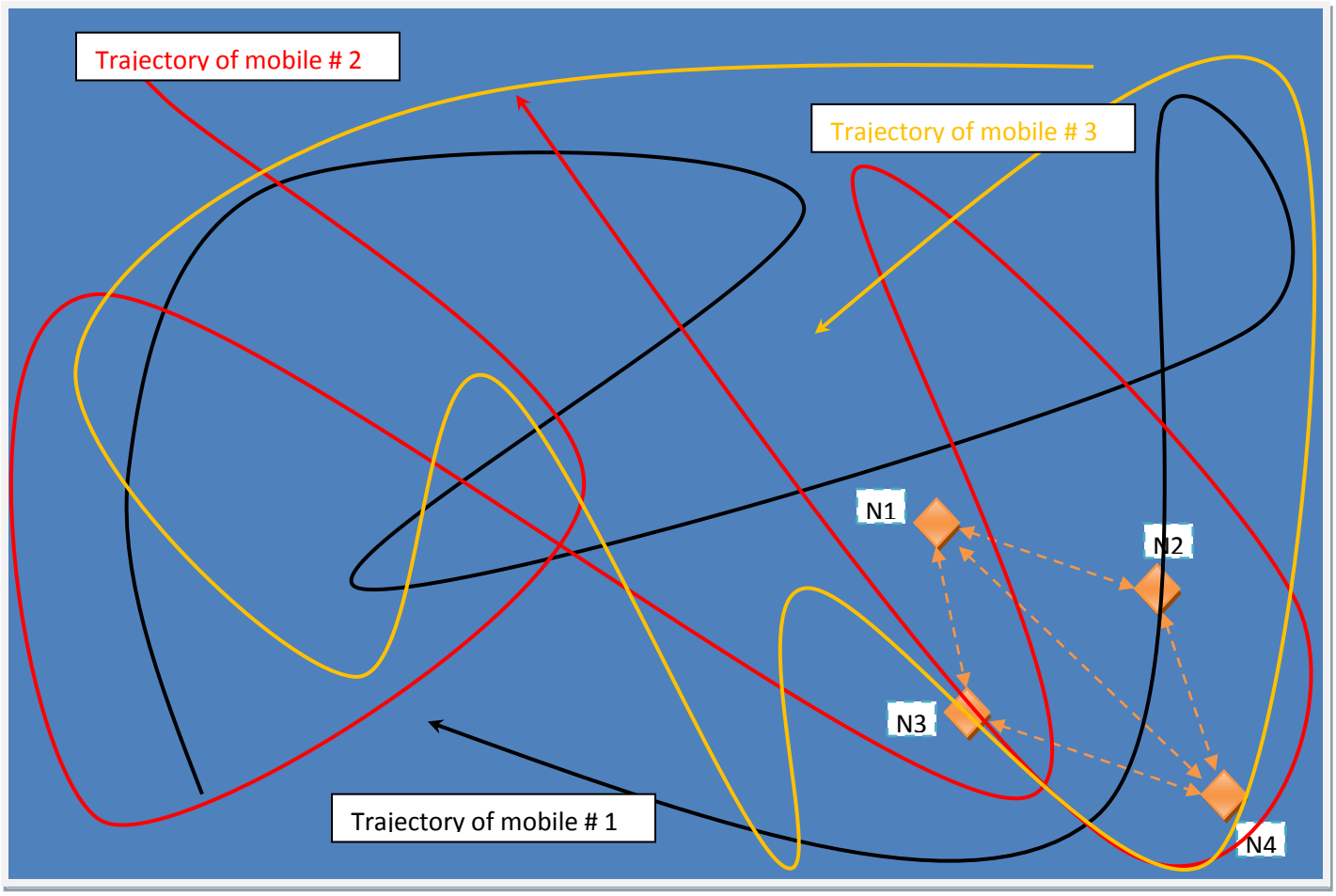



Figure 1: Example of network deployment for experiment 1 (UW-DTN), with three mobile nodes. The sink is N4.

## Experiment 2

*UW-Polling in operation.*

In this experiment, we test UW-Polling's capability to administer the upload of data from a network of fixed sensors to an AUV. One AUV follows a predefined cyclic course that makes it patrol the bottom-mounted nodes. All nodes periodically generate data. As the AUV passes by, the network transfers data to the AUV using UW-Polling's rules. In the end, we measure the packet delivery ratio for the whole network and as a function of the transmitter node; the latter is useful to compute the fairness of the "uploading service" provided by the AUV.

As a further experiment, we may perform exactly the same task, but using DACAP to deliver data from the bottom nodes to the AUV, instead of UW-Polling. UW-Polling is expected to work better.

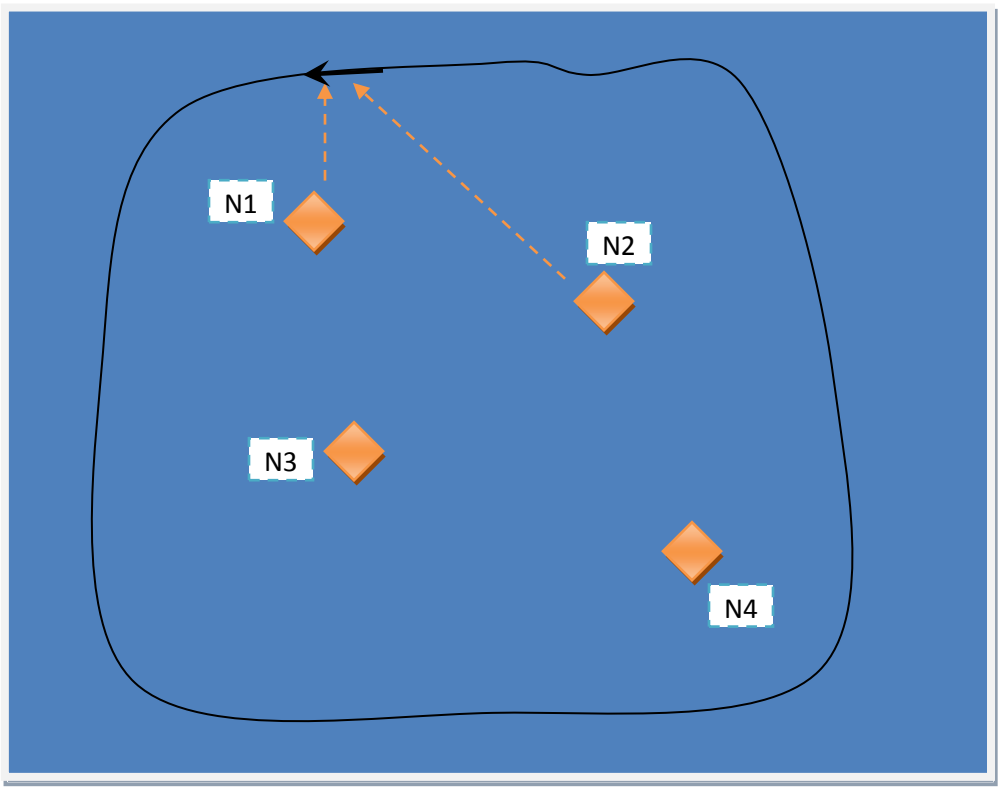



Figure 2: Example of network deployment for experiment 2 (UW-Polling). One mobile node patrols the network of fixed nodes to collect data.

## Experiment 3

*USR and fixed routes.*

In this experiment, we set up a sink (e.g., represented by a fixed node aboard a rubberboat) and convey data through the network to the sink. The data generation process at the nodes is configured to generate packets in "batches" (i.e., packets are delivered in groups from the application to the network protocols).The link-level protocol for data transfer is USR.

We can measure the packet delivery ratio, the packet delivery delay and the information throughput at the sink. As an extension, we can perform the same experiment by using DACAP or CSMA-ALOHA (along with error control in the form of Stop & Wait ARQ) as the link-level protocol.

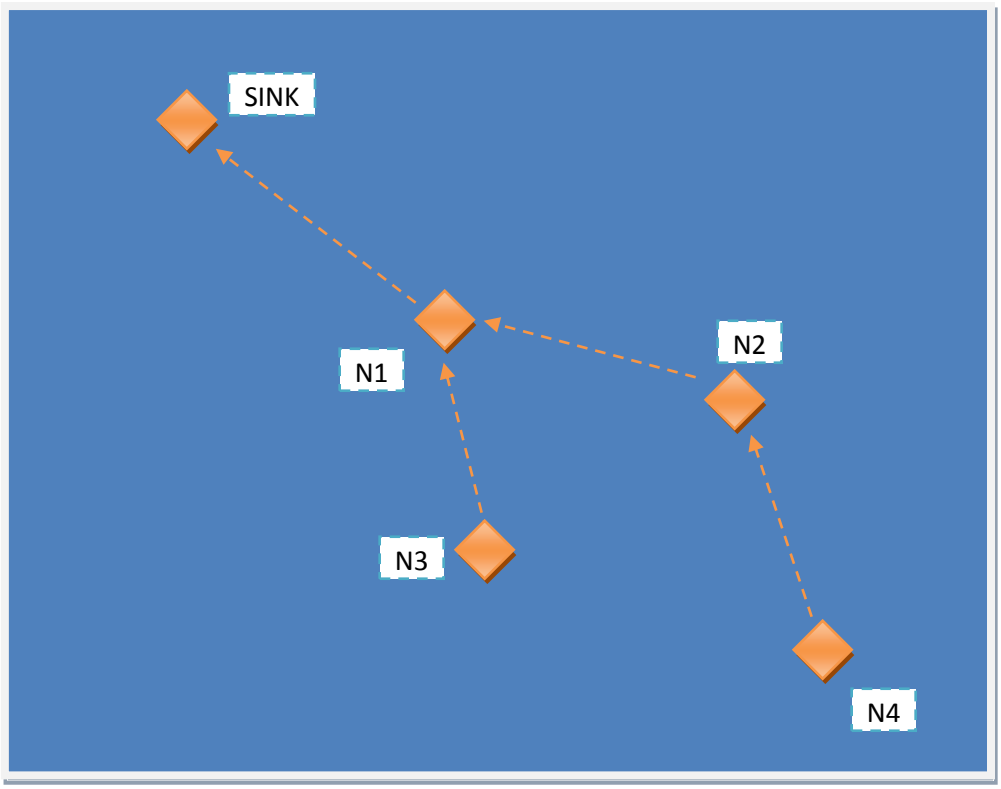



Figure 3: Routing from the network to a sink. The routes are static. Over each link, the transmission of data to the next hop is performed using USR.