Communicating Like Nemo: “Scale-ability” from a Fish-Eye View

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Abstract
Recreational scuba diving is a highly social activity where divers are encouraged to work in groups of two or more people. Though collaborative, divers are unable to freely and naturally communicate. Additionally, the lack of instincts to help them keep track of critical information such as time, depth, and direction further impairs their ability to engage in this underwater world. We propose the development of a collaborative based system, the Nemo2020, to increase activity-awareness, position-awareness, safety, and social integration for divers. Here we consider the design of this device, the ways in which current technology such as 802.11s Wi-Mesh and Android can be brought to bear on the problem, and how future systems may be able to rise to the challenge.

1 Design of the Nemo2020
The Nemo2020 is a collaborative dive computer system integrated with a messaging system, single and multiple divers’ status views, localization of divers’ position, and a safety alert enhancement. The device could be used standalone or in collaboration mode. In either mode, the system first leads the diver through a standard pre-dive procedure check (with the additional device pairing step), then enters the initial dive screen shown in Figure 1a. Divers click on an individual image to see details.

![Figure 1 Diver’s status screen and (b) Main menu screen in multi-system mode.](image)

In collaborative mode, a menu shows four options: “Message”, “Your Stats”, “Group Stats”, and “Position” (Figure 1b). “Group Stats” provides peer monitoring and cross-checking between divers as shown in Figure 2. The graph view enables divers to see detailed information of individual divers and is ideal for small groups; while, the table view offers an abstract view of every member’s status and can be scaled to a large number. Because water filters out spectrum colours as depth increases, our design uses patterns instead of colour to show the tank air volume in the table view.

The “Position” screen shows a compass and the relative position of other divers, as shown on the left side of Figure 3b. These divers can be in the same dive group or a different dive group, as long as they are in range. The circle in the middle of the screen shows the diver’s position; the triangle shows the position of other divers in the same group; the square shows the position of divers in other group(s). To cope with scalability issues, users are able to zoom in and out, similar to Google Maps.

Divers send messages to others by pressing either the “Message” button on the main menu or the icons in the position screen. Individual messages can be concatenated like fridge magnets shown in Figure 3, avoiding the need for fine grained motor activity such as typing.

![Figure 2 Group statistic screen: (a) graph view and (b) table view.](image)

Given the hostile electronic environment in which these devices are to operate, as well as the possibility of safety critical situations arising, it is important that appropriate levels of fault tolerance are included to ensure robustness. Most of these approaches are well known and will include information redundancy (use of codes), fault tolerant communication protocols, and some levels of hardware redundancy. These obviously have to be incorporated without compromising the usability of the devices.

2 Related Work
According to Kong et al. [6], the biggest differences between underwater-based and group-based mobile ad-hoc networking is the propagation delay, node mobility, and limited acoustic link capacity. In addition, underwater acoustic links have a low-bandwidth. To overcome these issues, Akyildiz et al. [1] have suggested a cross-layer approach, where communication functionalities are better integrated. Through simulation, Lee et al. [8] have shown that neither proactive nor reactive routing message is adequate in an underwater environment. In response, they have suggested an implementation of a multi-hop ad hoc network with no proactive routing and only a small amount of reactive floods.

In terms of existing dive computer products on the market, these include: consoles, wrist watches, face masks, full face masks,
and underwater cell phones. While the first three options only provide small text and no communication mechanism, the other two are comparatively more expensive and inconvenient to use, relative to the proposed ubiquitous design of the Nemo2020.

3 Inter-Communication Overheads

The Nemo2020 must operate in a highly dynamic mobile setting where we wish to support communication between small groups (e.g. three divers), large groups (e.g. 35 divers), multiple large groups (e.g. 4 groups of 35 divers), and possibly scale to an even larger size. We plan to deploy a hybrid network scheme, with acoustic communication underwater and radio communication between units at the surface. Radio communication (802.11 b/g) is applicable in the case where buoys are within range, but for larger scales communication we will resort to satellites. The on-surface units will act as portals supporting conversion between multiple technologies and facilitating communication between divers at long distances. In addition, the underwater communication will support ad-hoc settings where divers can reach one another without the need for a central access point. Due to the bandwidth constraints in an acoustic setting, the routing will be reactive as in [8], in an on-demand manner in order to minimize control messages used for setup and maintenance of the network. In this ad-hoc setting, any diver can access the gateway/buoy, in a one-hop or multi-hop manner, depending on their proximity to the access point. This requires the communication equipment on each diver to act as both user nodes and relay nodes.

Our current test-bed for emulating the hybrid network uses an 802.11s mesh network as supported by multiple One Laptop Per Child (OLPC) laptops as nodes. OLPCs by default are capable of forming mesh networks where nodes can act as regular, relay, or portals through lowering their transmission power (thus range) and bit-rate to better emulate the constraints of the underwater mesh setting. The on-surface gateways are emulated through the usage of off-the-shelf 802.11b/g routers, with transmit power and bit-rate tweaked.

4 Android and Data Intensive Applications

Based on the success Android has achieved in graphic intensive applications such as Global Time [3], AndroidScan, LifeAware, Locale, Marvin, and Talkplay [2], we believe Android is poised to offer the support we need for the Nemo2020. We envision future incarnations of the device to support features such as 3D enabled maps for navigation and positioning, image matching to future incarnations of the device to support features such as 3D to offer the support we need for the,” Ad

Table 1 Android API calls within sample applications.

<table>
<thead>
<tr>
<th></th>
<th>Calls to Android API</th>
<th>Total Lines of Application code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hello Android</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Notepad 3</td>
<td>247</td>
<td>287</td>
</tr>
<tr>
<td>Global Time</td>
<td>581</td>
<td>2466</td>
</tr>
</tbody>
</table>

With respect to the on-surface computing ability, with dual and quad core processors on a personal computer becoming commonplace and the future holding 100's of cores on a single chip, we want to make full use of these new resources at the application level, requiring a paradigm shift in the programming of these devices. To date, the complexity of programming for environments such as the Cell processor [5] has not been a priority.

Programming within this environment requires the development of new patterns and abstractions in isolation from these issues of modern resource utilization. We are currently exploring the feasibility of applying MapReduce [4] as a means of optimizing computation across future computational units. We envision substantial data sets processed by these units, and the optimization of these operations is critical so as to mitigate the substantial latencies inherent in the acoustic setting.

5 Conclusion

Water covers 71% of Earth’s surface, however, it has still yet to be fully explored. For this reason, it attracts millions of people each year to escape, explore, and experience this unknown. The Nemo2020 must be able to scale in terms of the number of divers involved, the user interface supported, the application functionality provided, and as well as the mobile ad hoc network as a whole. Further, we see variants of this device in the context of wilderness exploration in general, and foresee Android’s portability as a means of extending functionality beyond the underwater world. Please stay tuned for more adventures in the Bambi2022!

6 References


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