Improving WiFi communication with surface nodes at near-shore on tidal waters

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Abstract

We propose two link-design methods for improved communication between an onshore station and a surface node over tidal waters.

Method 1: for dynamic surface nodes
It identifies a favorable distance region for good communication quality at each point of the tide.

Method 2: for stationary surface nodes
It determines the optimal height/distance region that minimizes the path loss averaged during the whole tidal cycle.
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**Wireless radio links** deployed over aquatic areas are strongly affected by the conductive properties of the **water surface**, strengthening **signal reflections** and increasing interference effects [1].

![Diagram](image)

**2-ray model** [2]

\[ h_0 \quad h_t \]

average water level

signal reflection

water level shift due to tides

\[ d \]

onshore station

surface node

surface plane

\[ \Delta_k \]

**Improving WiFi communication with surface nodes**


Recurrent natural phenomena such as tides or waves cause shifts in the water level that, in turn, change the interference patterns [3].

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Shift on the receiver height e.g., $\Delta_k = 2$ cm

**Scenario 1: Shore-to-AUV Wi-Fi link in LOS**

**Method 1:** We determined a convenient distance to shore that will lead to **sustained high signal strength** in a broad region so that the vehicle can be driven to that distance and initiate **communication with high quality.**
Experimental results clearly show the validity of our Link Quality Model (LQM) and the interest of method 1.

**RSSI measurements**

**Analytical results** (two-ray model)

- Clear match with the 2-ray model estimates
- Favorable transition
- Unfavorable transition
- >15-20dB gain and better stability
Experimental results clearly show the validity of our Link Quality Model (LQM) and the interest of method 1.

\( h_{\text{Tx}} \approx 4.4 \text{ m} \)

\( h_{\text{Tx}} \approx 4.7 \text{ m} \)

Shift on the water level e.g., \( \Delta_k = 30 \text{ cm} \)
**Scenario 2: Shore-to-Buoy link in LOS**

**Method 2:** Based on [4] we reduced the so-called **tidal fading** by acting on the **antenna height or link distance** to minimize the average path loss over a full tidal cycle, providing the **best channel conditions on average.**
Scenario 2: Shore-to-Buoy link in LOS

Method 2: Based on [4] we reduced the so-called tidal fading by acting on the antenna height or link distance to minimize the average path loss over a full tidal cycle, providing the best channel conditions on average.

\[ f = 2.4\text{GHz} \hspace{1em} h_r = 0.6\text{m} \]

Scenario 2: Shore-to-Buoy link in LOS

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### Scenario 2: Shore-to-Buoy link in LOS

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<table>
<thead>
<tr>
<th>Antenna Height (m)</th>
<th>Avg. Path Losses (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

- *f=2.4GHz hr=0.3m*
- *f=5GHz hr=0.3m*
- *Scenario 2: Shore to Buoy link in LOS*

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Conclusions

This work provides novel **positioning** and **antenna-design** methods to **mitigate the impact of tides** on the LOS shore-to-surface channel.

We also provided a novel and clear **experimental validation** of the two-ray model with Wi-Fi technology over water at near-shore.

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Thank you!