

# EM channel– Quick how-to and exercises

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**Padova (Italy)**

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Riccardo Tumiatì, Filippo Campagnaro, Michele  
Zorzi



[riccardo.tumiatì@wirelessandmore.it](mailto:riccardo.tumiatì@wirelessandmore.it), [filippo.campagnaro@unipd.it](mailto:filippo.campagnaro@unipd.it)

# EM– tcl examples

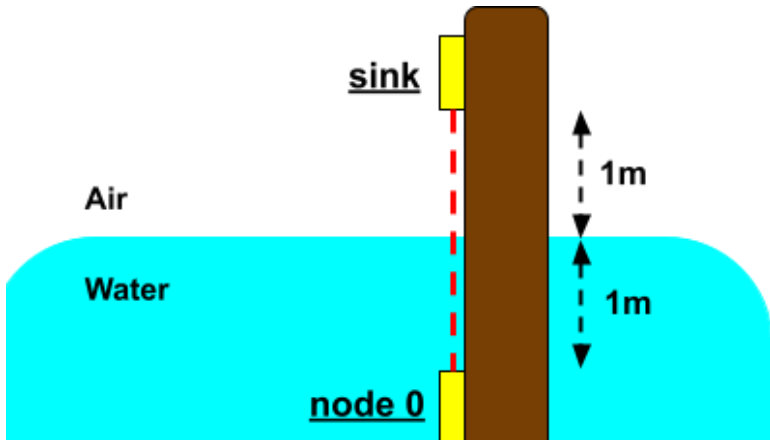
- Navigate in the desert with em example folder
  - `cd /DESERT_Framework/DESERT/samples/desert_samples/PHY/EM`

Today we analyze two examples:

- **test\_uwem\_prop.tcl**
  - Single hop simulation
- **test\_uwem\_prop\_multihop.tcl**
  - Multi hop simulation

# test\_uwem\_prop.tcl

Node 0	Sink
7. UW/CBR	7. UW/CBR
6. UW/UDP	6. UW/UDP
5. UW/STATICROUTING	5. UW/STATICROUTING
4. UW/IP	4. UW/IP
3. UW/MLL	3. UW/MLL
2. UW/CSMA_ALOHA	2. UW/CSMA_ALOHA
1. UW/ElectroMagnetic/PHY	1. UW/ElectroMagnetic/PHY
propagation	
UnderwaterChannel	



# test\_uwem\_prop.tcl

- LUT in /DESERT\_Framework/DESERT/samples/desert\_samples/dbs/em\_attenuation/CR\_4-5 and /DESERT\_Framework/DESERT/samples/desert\_samples/dbs/em\_attenuation/CR\_4-8
- Scenario: 1 nodes, one sink
- Nodes dept = 1 m
- Sink altitude = 1 m
- cbr period = 60 s
- packet size = 125 bytes
- freq. 868 MHz, bw 125 kHz
- bitrate = 27 kbps
- tx power = 14 dB
- antenna gain = 2 dBi
- temperature = 20 °C
- salinity = 0 (g/kg)<sup>2</sup> (freshwater)
- spreading factor = 7
- code rate = 4/5

## LUT SF\_7 CR\_4/5

RSSI (dBm)	PL (%)
< -109.45	100
-109.45	6.5
-97.75	2.5
> -97.75	2.5

# test\_uwem\_prop.tcl - results

```
-----  
Simulation summary  
packet size      : 125 byte  
cbr period       : 60 s  
simulation length: 99999 s  
tx frequency     : 868000000 Hz  
tx bandwidth     : 125000 Hz  
bitrate          : 27000 bps  
-----  
Throughput       : 16.276342  
Sent Packets     : 1666.0  
Received Packets : 1627.0  
Packet Delivery Ratio : 97.659063625450187  
IP Pkt Header Size : 2  
UDP Header Size   : 2  
CBR Header Size   : 12
```

$G = \text{packet size} / \text{cbr period} = 16.66 \text{ bps}$

Throughput  $\approx G * \text{Packet Delivery Ratio}$

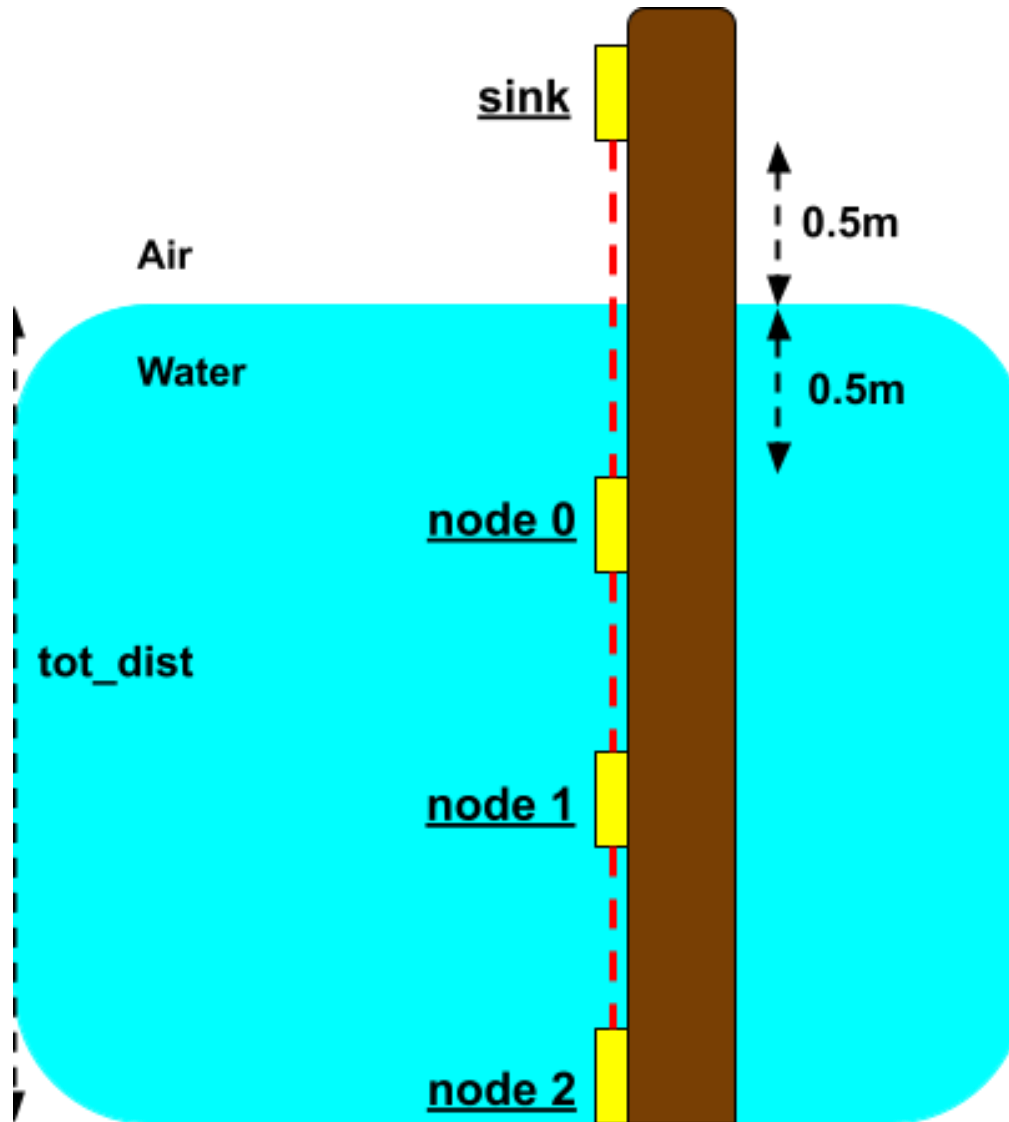


# test\_uwem\_prop.tcl - limits

- Experimentally find the maximum node depth after which all the packets are dropped
- Experimentally find the maximum water salinity after which all the packets are dropped

What did you find? How can we reduce the strong attenuation in these cases? Try it

# test\_uwem\_prop\_multihop.tcl



# test\_uwem\_prop\_multihop.tcl

Node 1		Node 0		Sink	
+-----+		+-----+		+-----+	+-----+
7. UW/CBR		7. UW/CBR		7. UW/CBR	UW/CBR
+-----+		+-----+		+-----+	+-----+
6. UW/UDP		6. UW/UDP		6. UW/UDP	
+-----+		+-----+		+-----+	+-----+
5. UW/STATICROUTING		5. UW/STATICROUTING		5. UW/STATICROUTING	
+-----+		+-----+		+-----+	+-----+
4. UW/IP		4. UW/IP		4. UW/IP	
+-----+		+-----+		+-----+	+-----+
3. UW/MLL		3. UW/MLL		3. UW/MLL	
+-----+		+-----+		+-----+	+-----+
2. UW/CSMA_ALOHA		2. UW/CSMA_ALOHA		2. UW/CSMA_ALOHA	
+-----+		+-----+		+-----+	+-----+
1. UW/ElectroMagnetic/PHY		1. UW/ElectroMagnetic/PHY		1. UW/ElectroMagnetic/PHY	
+-----+		+-----+		+-----+	+-----+
+-----+		+-----+		+-----+	+-----+
+-----+		+-----+		+-----+	+-----+
UnderwaterChannel					
+-----+		+-----+		+-----+	+-----+



# test\_uwem\_prop\_multihop.tcl

- LUT in /DESERT\_Framework/DESERT/samples/desert\_samples/dbs/em\_attenuation/CR\_4-5 and /DESERT\_Framework/DESERT/samples/desert\_samples/dbs/em\_attenuation/CR\_4-8
- Scenario: 4 nodes, one sink
- Distance to cover = 5 m
- Sink altitude = 0.5 m
- cbr period = 60 s
- packet size = 125 bytes
- freq. 868 MHz, bw 125 kHz
- bitrate = 27 kbps
- tx power = 14 dB
- antenna gain = 2 dBi
- temperature = 20 °C
- salinity = 0 (g/kg)<sup>2</sup> (freshwater)
- spreading factor = 7
- code rate = 4/5

## LUT SF\_7 CR\_4/5

RSSI (dBm)	PL (%)
< -109.45	100
-109.45	6.5
-97.75	2.5
> -97.75	2.5

# ...\_multihop.tcl - results

```
-----  
Simulation summary  
number of nodes   : 5  
distance to cover: 5 m  
packet size       : 125 byte  
cbr period        : 60 s  
simulation length: 9999 s  
tx frequency      : 868000000 Hz  
tx bandwidth      : 125000 Hz  
bitrate           : 27000 bps  
-----  
cbr_sink(4)(-5.000000) throughput           : 14.555987  
cbr_sink(4)(-5.000000) forward-trip-time    : 0.567384  
cbr_sink(3)(-3.875000) throughput           : 15.149222  
cbr_sink(3)(-3.875000) forward-trip-time    : 0.501905  
cbr_sink(2)(-2.750000) throughput           : 15.258983  
cbr_sink(2)(-2.750000) forward-trip-time    : 0.411256  
cbr_sink(1)(-1.625000) throughput           : 15.962007  
cbr_sink(1)(-1.625000) forward-trip-time    : 0.273737  
cbr_sink(0)(-0.500000) throughput           : 16.464147  
cbr_sink(0)(-0.500000) forward-trip-time    : 0.133034  
Mean Throughput           : 15.478069199999998  
Mean Forward-Trip-Time    : 0.3774632  
Sent Packets              : 830.0  
Received Packets          : 770.0  
Packet Delivery Ratio     : 92.771084337349393  
IP Pkt Header Size        : 2  
UDP Header Size           : 2  
CBR Header Size           : 12
```



# ...\_multihop.tcl - output format

- In the TCL file:
  - Switch \$simulation\_files from 0 to 1
  - Run again the simulation

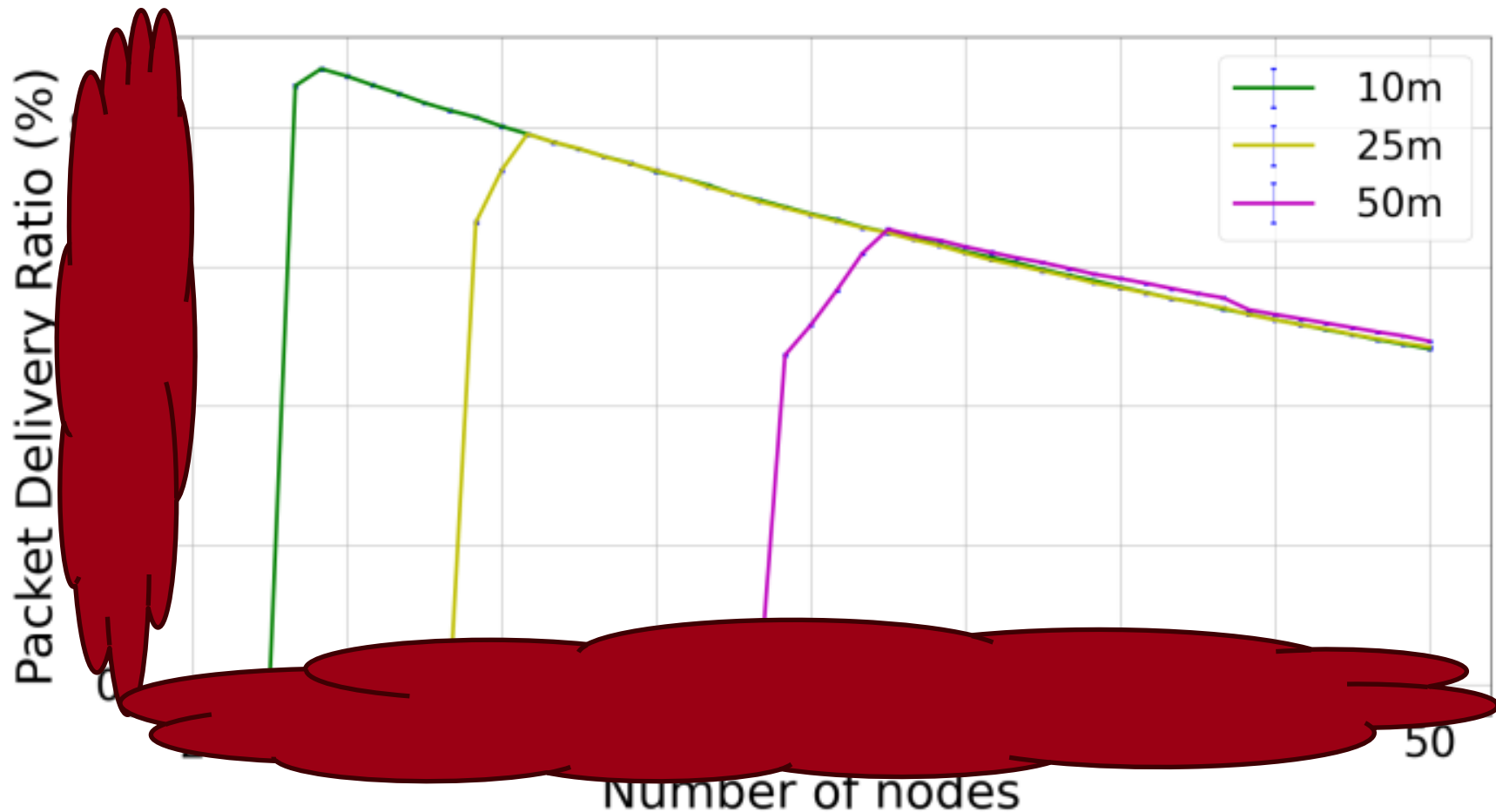
```
15.419592399999999,92.53012048192771,0.38052980000000003
```

- You will compress the previous output, being ready to simulate multiple times with a bash file

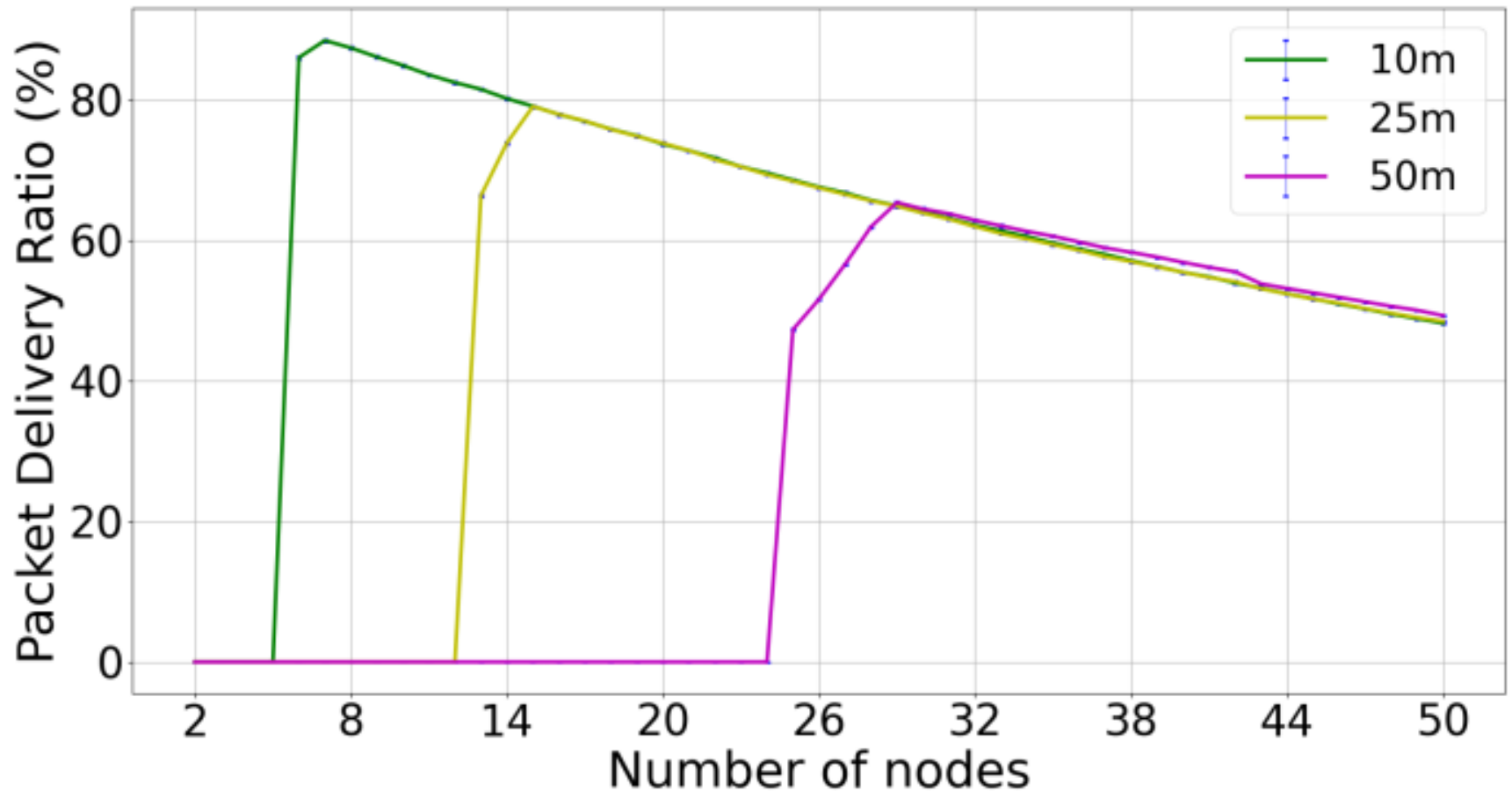
# ...\_multihop.tcl - Exercise 1

- Objective: for different depths find the optimal number of nodes to place in the pole
- KPI to consider: Packet Delivery Ratio
- $d = 10\text{m}, 25\text{m}, 50\text{m}$
- Number of nodes = 2 – 50
- Number of repetitions = 5 (for CI computation)
- Other parameters: as before

# ...\_multihop.tcl - expected results



## ...\_multihop.tcl - results



## ...\_multihop.tcl - conclusions

- What is the optimal number of nodes for the different cases?
- What is the intermediate node distance?
- Why performance degrades after a certain point?
- For a certain depth there is a max Packet Delivery Ratio, what can we do better?