



**FUTEBOL**

Federated Union of Telecommunications  
Research  
Facilities for an EU-Brazil Open Laboratory

# Adaptive MAC (TDMA/CSMA)

*Based on paper "FS-MAC: Uma Plataforma para a Flexibilização da Sub-Camada MAC em Redes Sem Fio", presented in the main track of SBRC 2017*

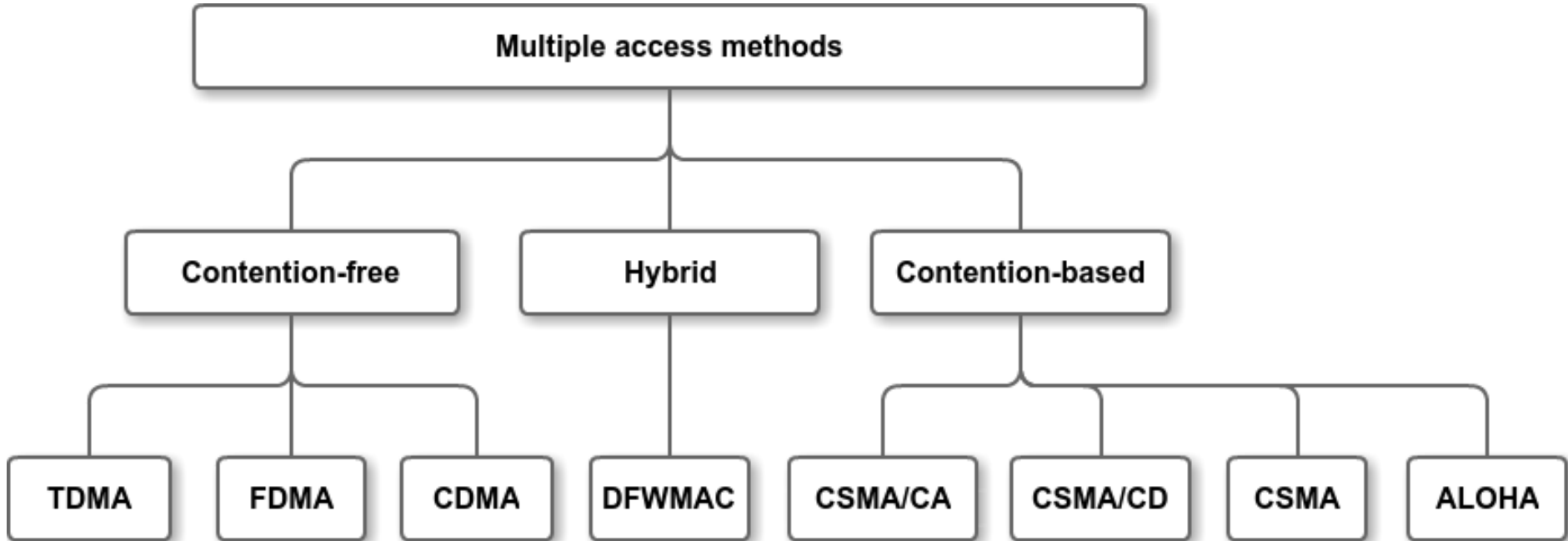


# Dynamic change of the MAC protocol in WPANs



- The MAC protocol influences the performance of a WPAN network.
- Each family of protocols (contention-based and contention-free) perform best on certain scenarios.

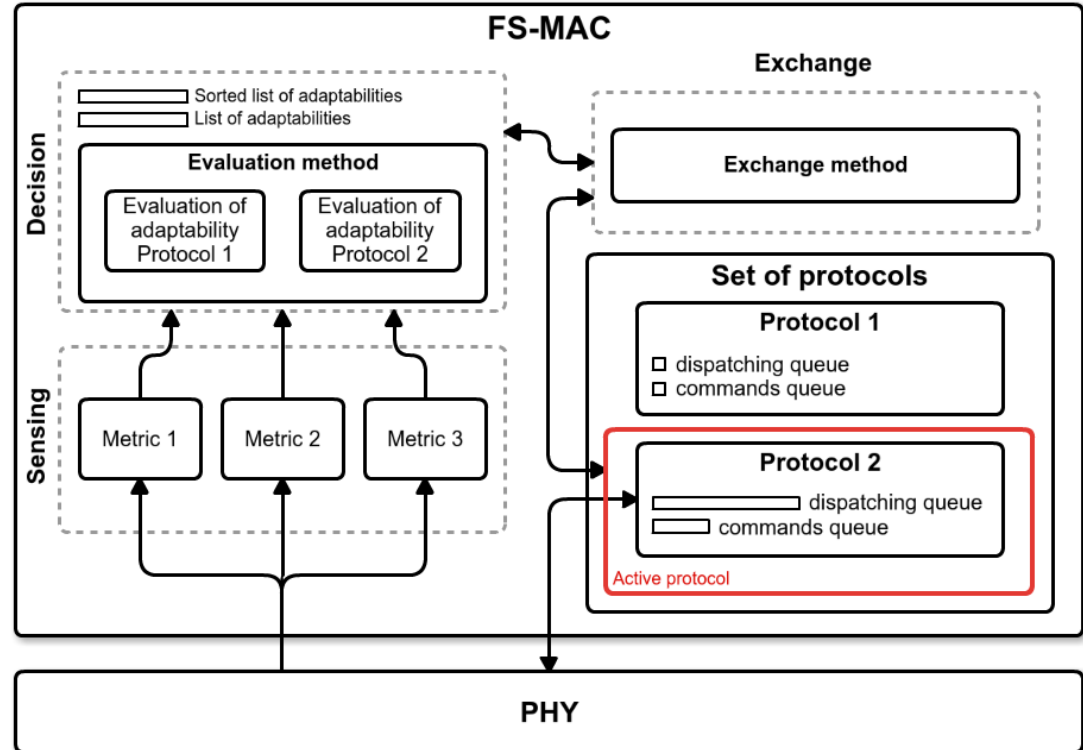
# MAC protocols



# Architecture of FS-MAC



- Dynamic change between CSMA and TDMA over IEEE 802.15.4
- Decision of best protocol uses a fuzzy inference engine



# FS-MAC – Fuzzy System



- Fuzzy system uses the information about **number of senders** and **packet delivery latency** to infer the contention level of the network
- The system classifies, for each protocol, if the performance of the protocol would be HIGH, MEDIUM or LOW for the current network conditions

# Fuzzy system - Details



Linguistic variables

- Average latency of packet delivery (**AL**),
- Number of senders (**NS**)
- Adaptability of the protocol (**ADP**).

They all accept the fuzzy terms **LOW** and **HIGH**.

# Fuzzy rules



## CSMA

If NS is **LOW** and AL is **HIGH** then ADP is **HIGH**

If NS is **LOW** and AL is **LOW** then ADP is **HIGH**

If NS is **HIGH** and AL **HIGH** then ADP is **LOW**

If NS is **HIGH** and AL is **LOW** then ADP is **HIGH**

## TDMA

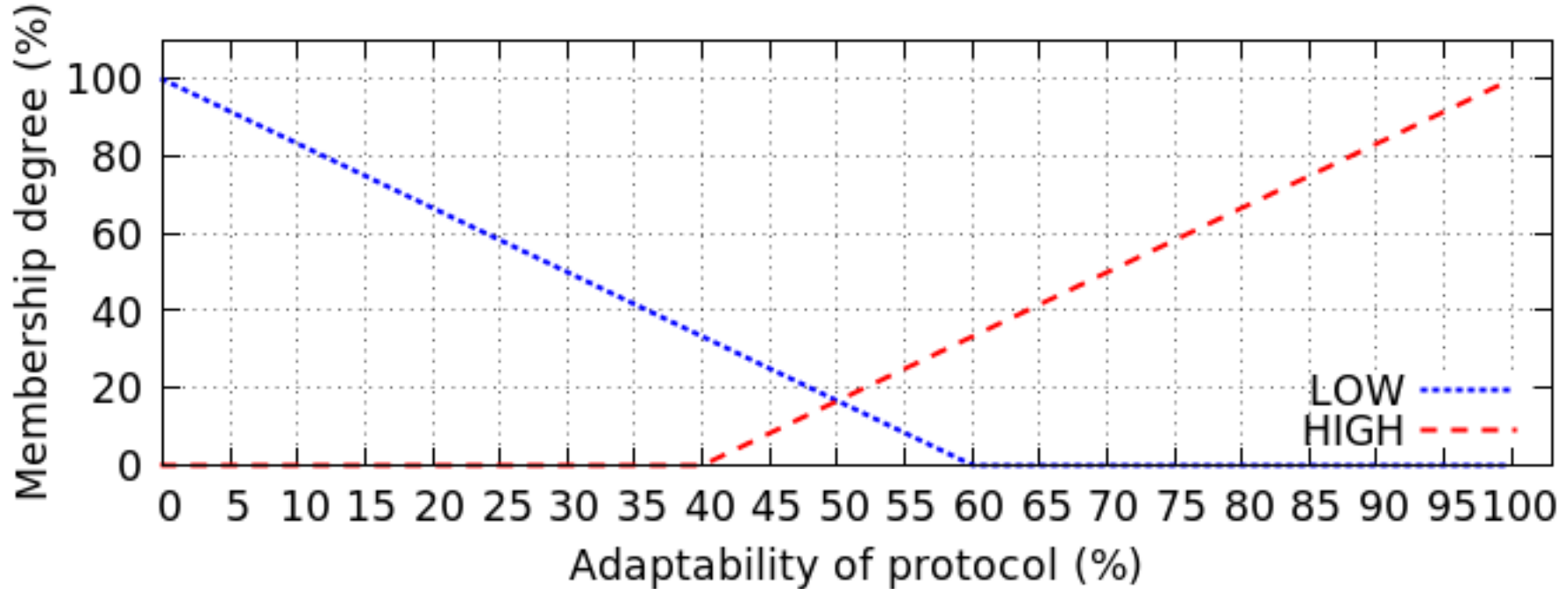
If NS is **LOW** and AL is **HIGH** then ADP is **LOW**

If NS is **LOW** and AL is **LOW** then ADP is **LOW**

If NS is **HIGH** and AL is **HIGH** then ADP is **HIGH**

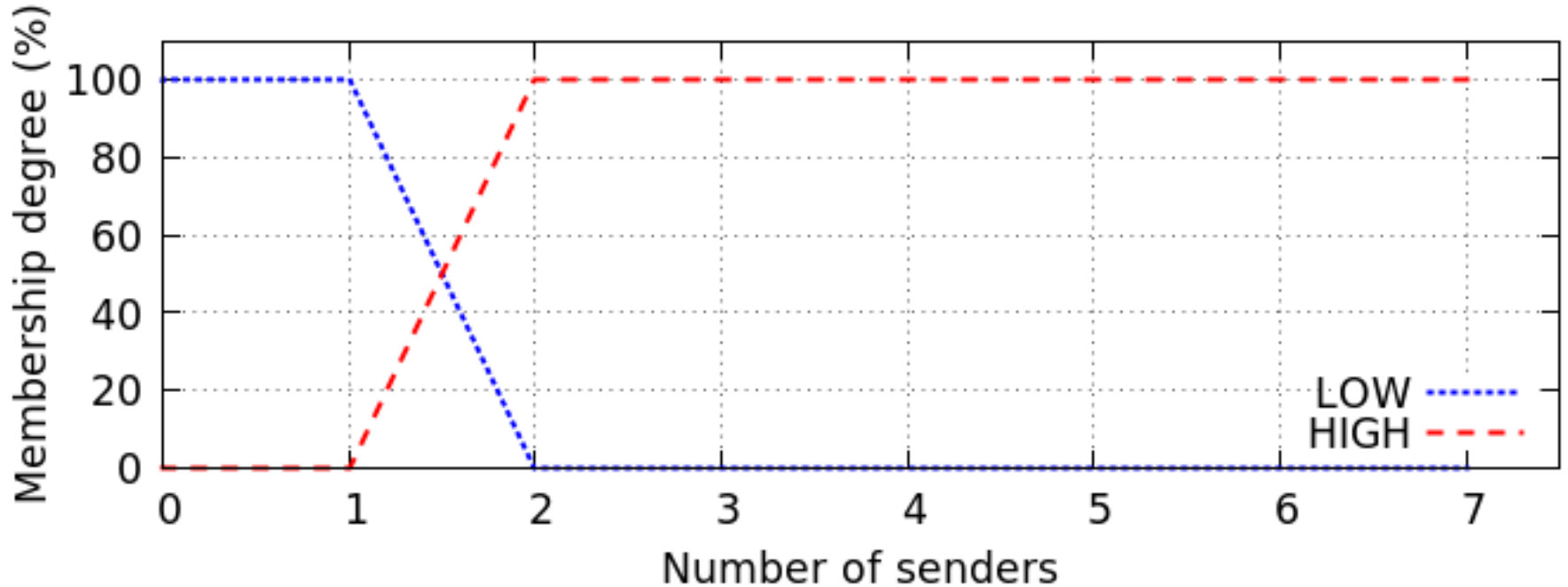
If NS is **HIGH** and AL is **LOW** then ADP is **LOW**

# Membership functions

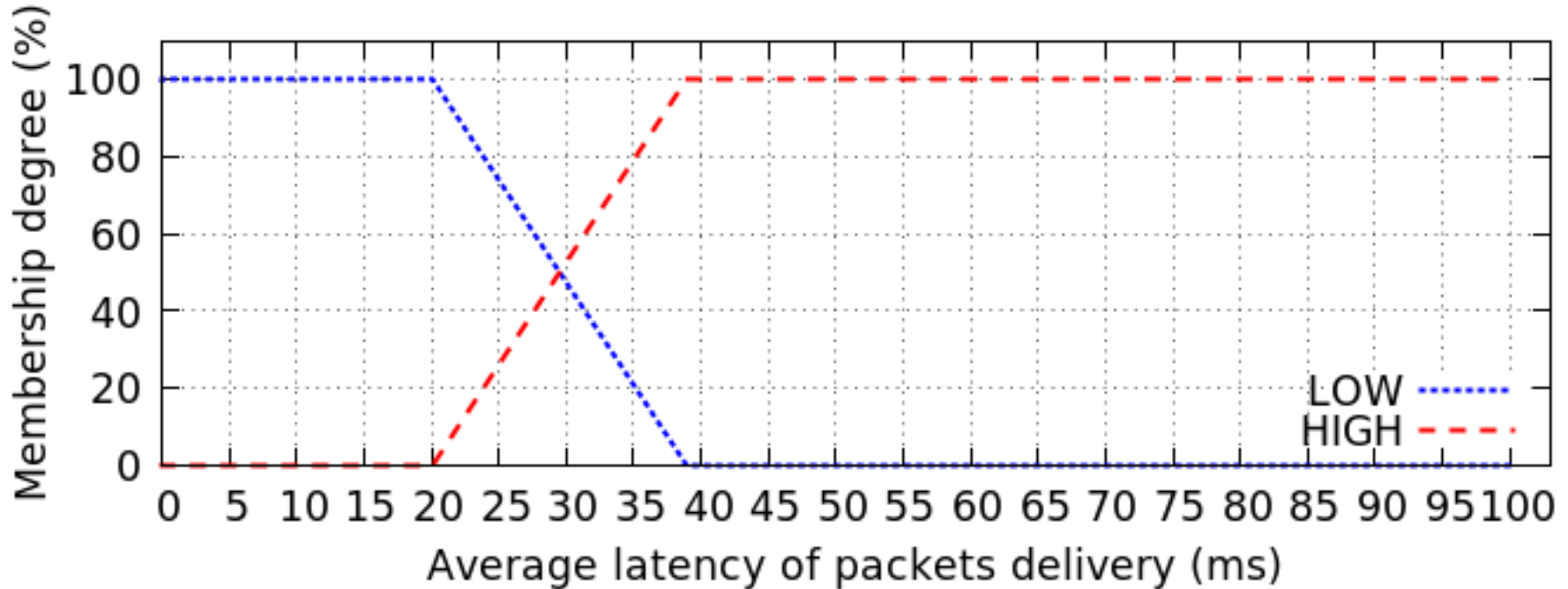




# Membership functions

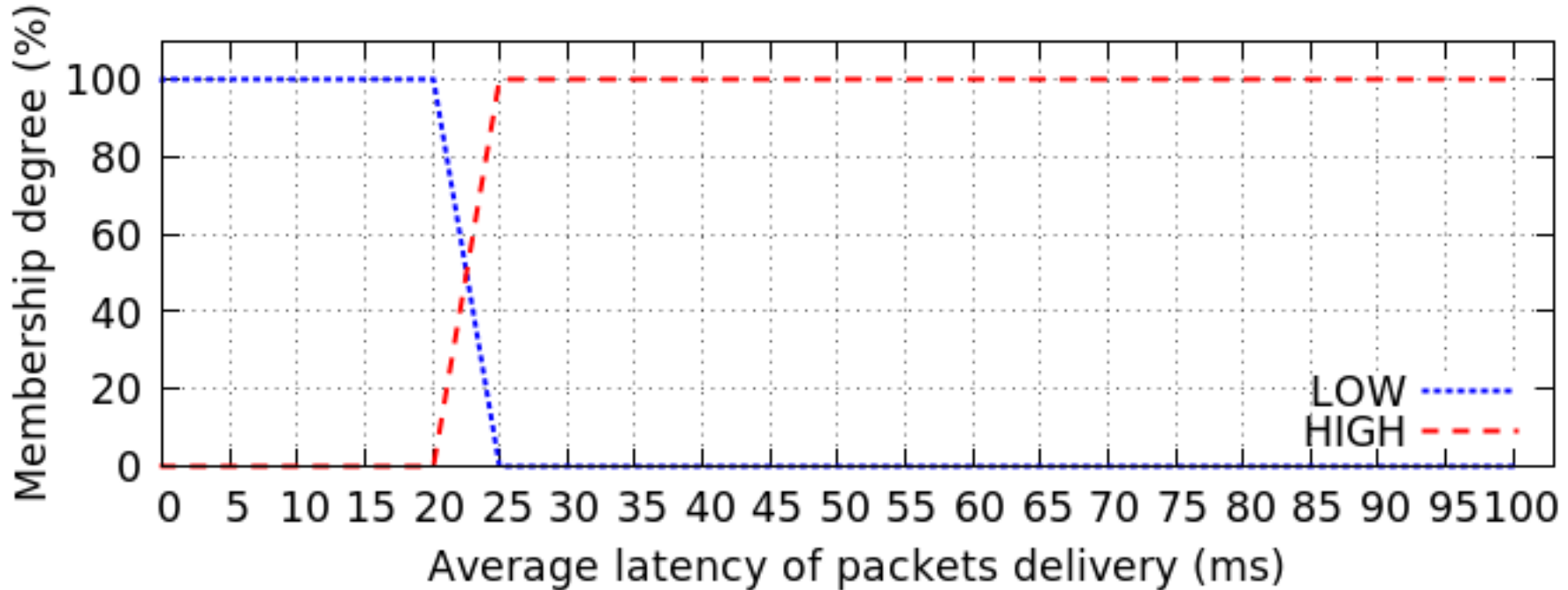


# Membership functions



CSMA

# Membership functions



TDMA

# General dependencies



- Projects

- <https://github.com/osh/gr-eventstream>
- <https://github.com/osh/gr-uhdgps>
- <https://github.com/bastibl/gr-foo>
- <https://github.com/bastibl/gr-ieee802-15-4>
- <https://github.com/jeffRayneres/FS-MAC>

- Libraries

[swig, liblog4cpp5-dev, python-matplotlib, libboost-all-dev](#)

# Configuring the testbed



```
git clone https://github.com/jeffRayneres/FS-MAC
```

In directory **/gr-fsmac/examples** of the FS-MAC platform there is a RSpec file to be used with jFed for resource allocation.

The file **DynamicChange.rspec** reserves three nodes in FUTEBOL UFMG testbed.

# Installing dependencies



In the FS-MAC github project, there is a bash file to install and configure the platform and all the dependencies. For this, execute the following commands:

1. `git clone https://github.com/jeffRayneres/FS-MAC`
2. `cd FS-MAC`
3. `chmod +x install.sh`
4. `./install.sh`

# Installing dependencies



The bash file **install.sh** will:

- Download and install the libraries
- Download, install and configure the projects
- Configure the PHY layer of ZigBee project

# Dynamic Change Experiment 1



The objective of the experiment is to change the MAC protocol automatically, according to rules based on the amount of contention on the wireless medium.

Those rules are part of the fuzzy system.



# Dynamic Change Experiment 1



At this point, we have already allocated three nodes in the testbed and installed the dependencies on each one.

In directory **FS-MAC/gr-fsmac/examples** there are the scripts **transceiverStation1.py**, **transceiverStation2.py** and **transceiverStation3.py**

The experiment has three simple steps

# Dynamic Change Experiment 1



Station 1

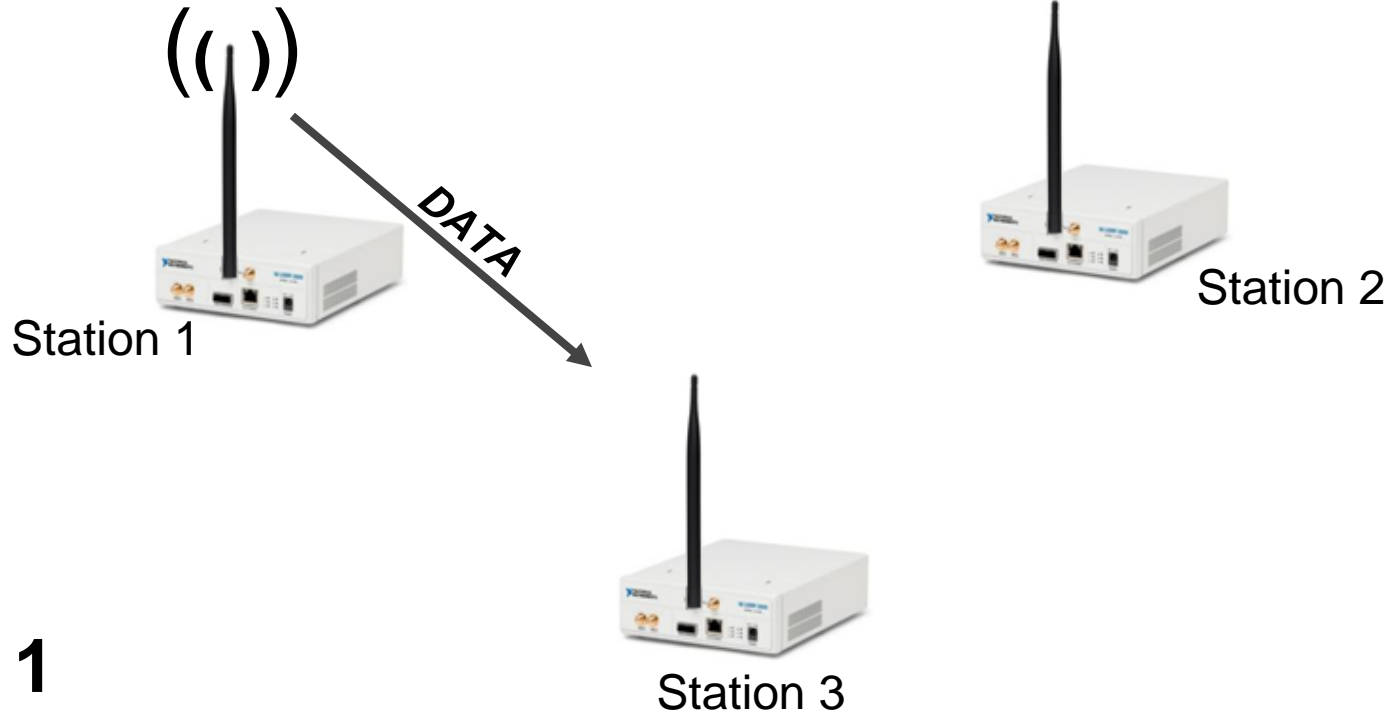


Station 2

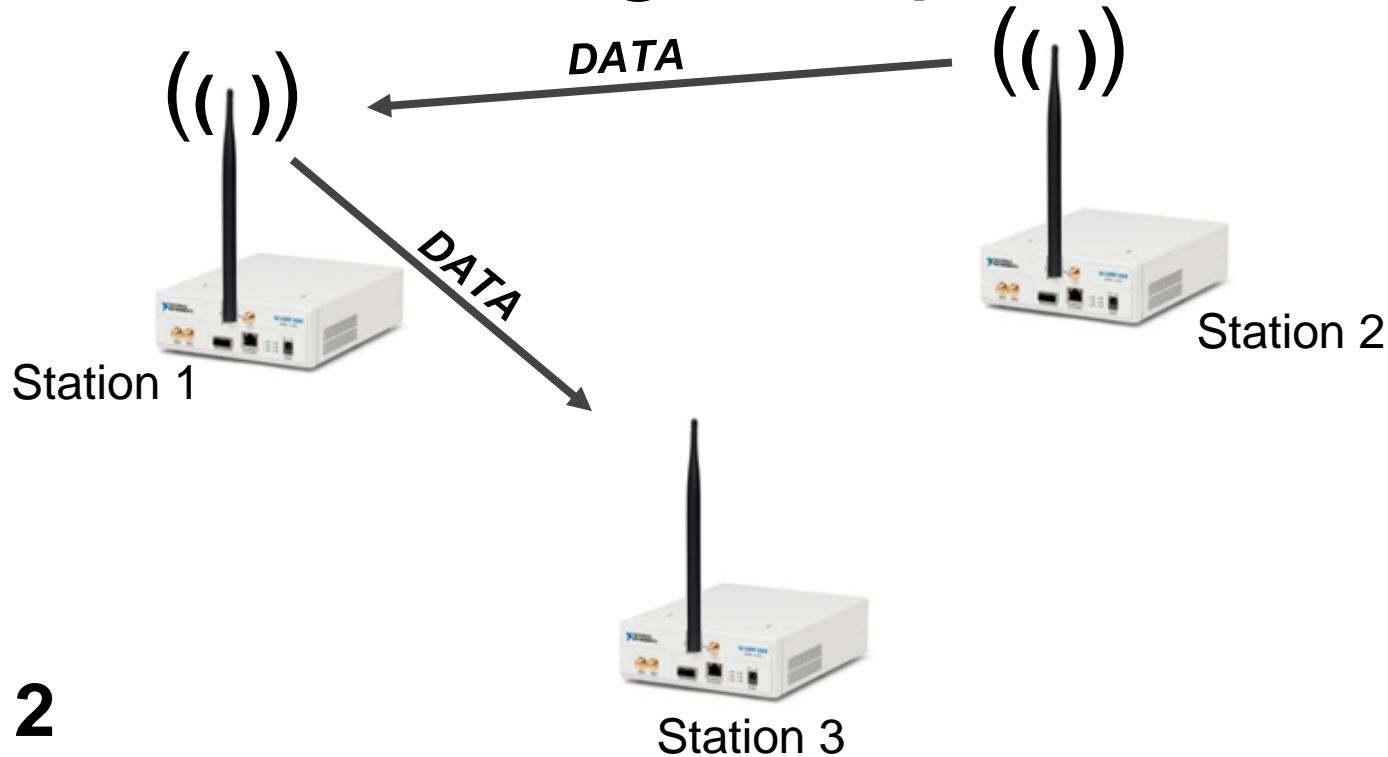


Station 3

# Dynamic Change Experiment 1

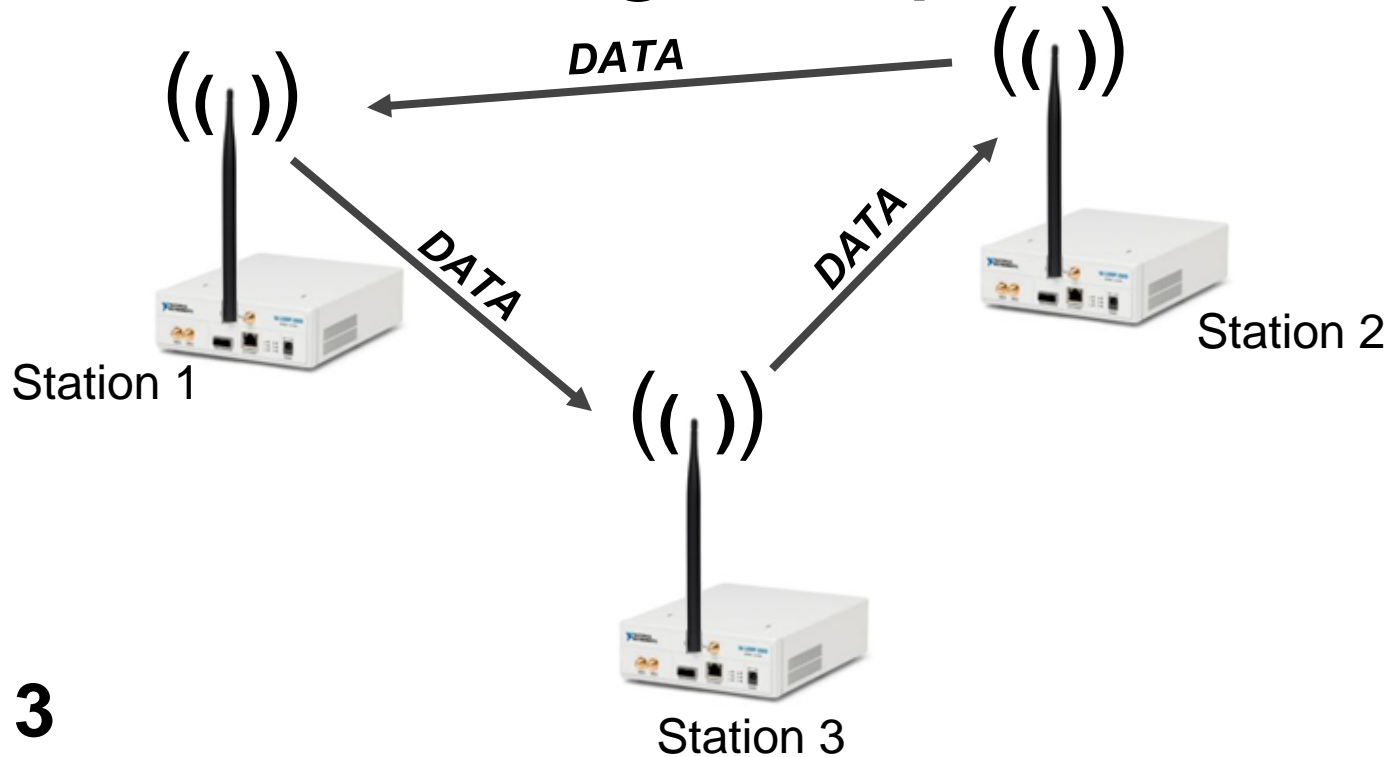


# Dynamic Change Experiment 1



**Step 2**

# Dynamic Change Experiment 1



**Step 3**

# Dynamic Change Experiment 1



Step 1: Run the **transceiverStation1.py** in Station 1

Step 2: Run the **transceiverStation2.py** in Station 2

Step 3: Run the **transceiverStation3.py** in Station 3

The time interval between each step should be **15 seconds**.

# Dynamic Change Experiment 1



In terminal of **Station1** we can see the Number of senders (NS) value information.

In terminal of all stations we can see what is the active protocol and the log of sent packets

# Dynamic Change Experiment 1



Protocol operating after each step must be

Step 1: CSMA

Step 2: TDMA

Step 3: TDMA





```
Terminal
Arquivo Editar Ver Pesquisar Terminal Ajuda
ACTIVE PROTOCOL: CSMA

NS: 1
ACTIVE PROTOCOL: CSMA

NS: 1
ACTIVE PROTOCOL: CSMA

NS: 2
ACTIVE PROTOCOL: CSMA

Exchanging...

New protocol activated!

NS: 2
ACTIVE PROTOCOL: TDMA

NS: 2
ACTIVE PROTOCOL: TDMA

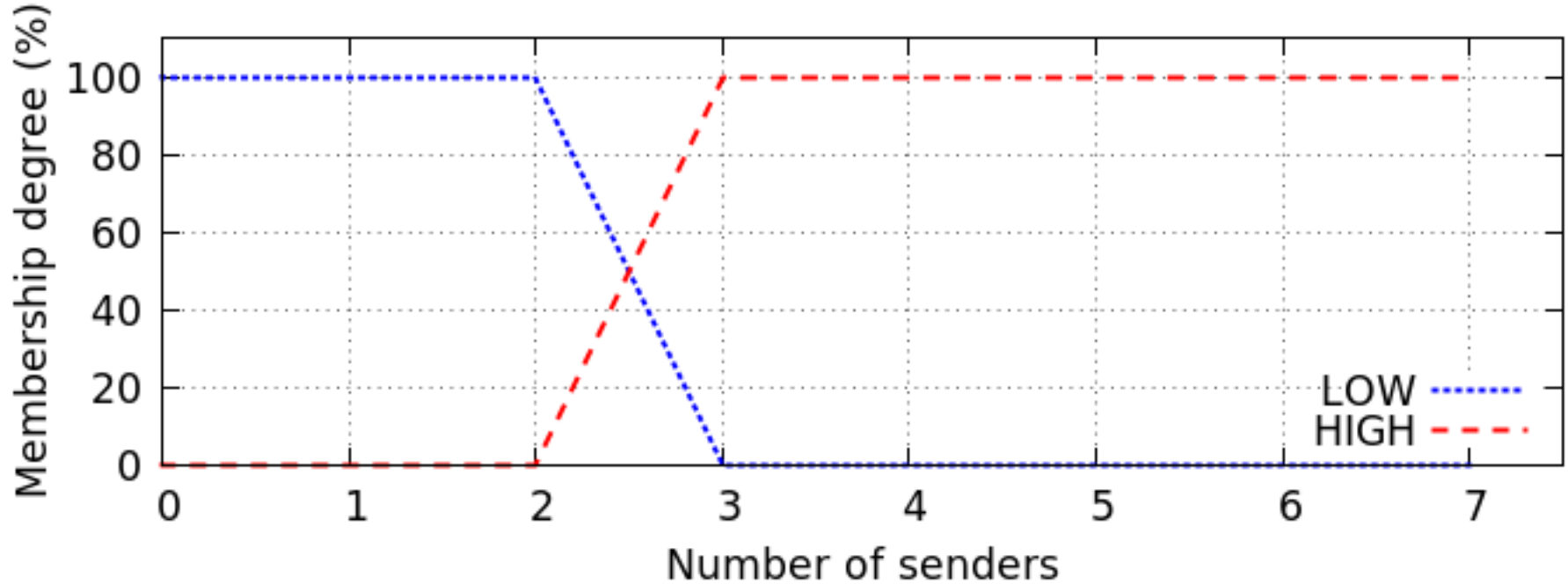
NS: 2
ACTIVE PROTOCOL: TDMA
```

# Dynamic Change Experiment 2

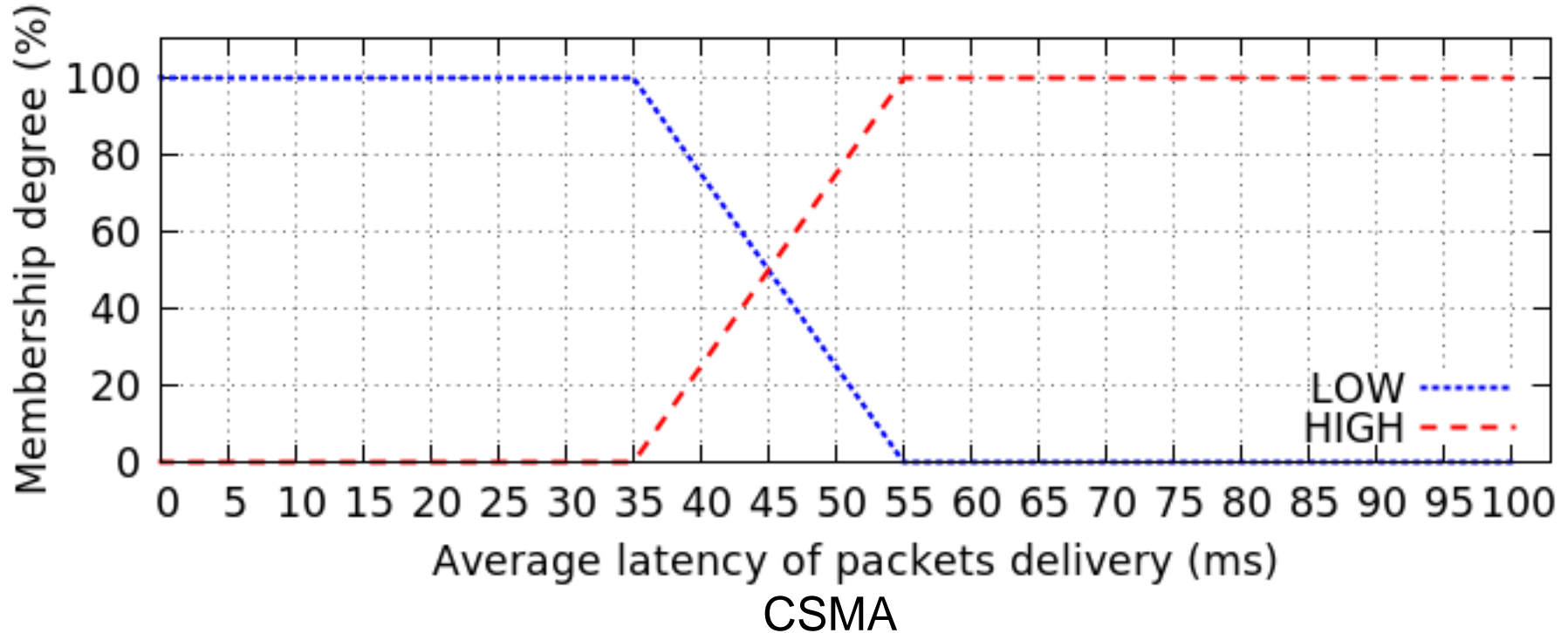


The purpose of this experiment is to change the rules of the fuzzy system so that the MAC protocol exchange occurs at a different contention level

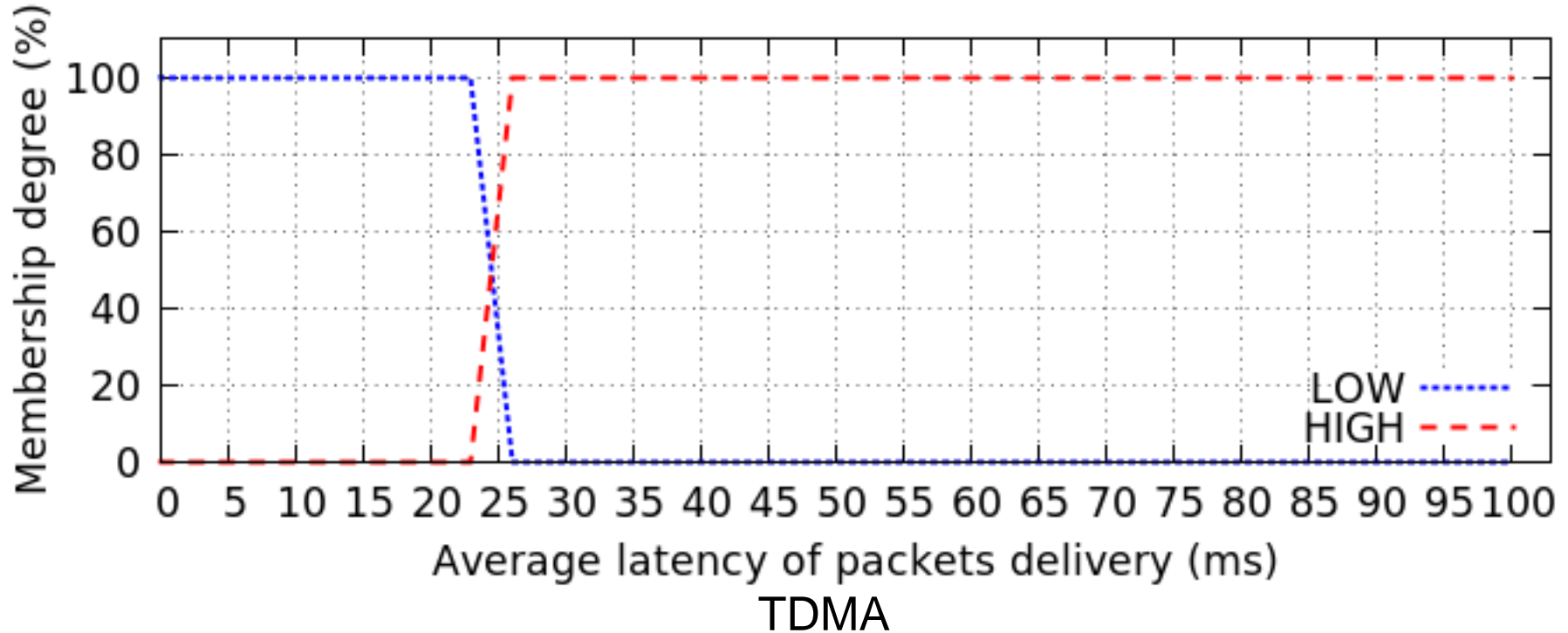
# New membership functions



# New membership functions



# New membership functions



# Dynamic Change Experiment 2



We need to change the **decision.py** file in the **FS-MAC/gr-fsmac/python** directory of the FS-MAC coordinator (**Station1**)

In this file, we need to change the functions **senders\_function()** and **data\_function()**

The new implementation is in the file, but commented. Just uncomment this code, comment the code of the current implementation and reinstall FS-MAC project.

# Dynamic Change Experiment 2



To reinstall FS-MAC project, access **FS-MAC/gr-fsmac/build** directory and execute the following commands:

1. `sudo make install`
2. `sudo ldconfig`

# Dynamic Change Experiment 2



Repeat the three steps of the experiment. This time, the protocol operating after each step must be

Step 1: CSMA

Step 2: CSMA

Step 3: TDMA





Terminal  
Arquivo Editar Ver Pesquisar Terminal Ajuda

ACTIVE PROTOCOL: CSMA

NS: 2

ACTIVE PROTOCOL: CSMA

NS: 2

ACTIVE PROTOCOL: CSMA

NS: 2

ACTIVE PROTOCOL: CSMA

NS: 3

ACTIVE PROTOCOL: CSMA

Exchanging...

New protocol activated!

NS: 3

ACTIVE PROTOCOL: TDMA

NS: 3

ACTIVE PROTOCOL: TDMA

# Thank You!

## Questions? Comments?



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