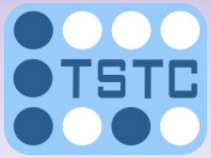

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An XML-Based Approach to the Configuration and Deployment of DDS Applications

Javier Sanchez-Monedero (javism at correo.ugr.es)
Javier Povedano Molina, Jose M. Lopez-Vega &
Juan M. Lopez-Soler
Signal Theory, Telematics and Communications Dept.
University of Granada

Workshop on Distributed Object Computing for Real-time and Embedded Systems
July 15, 2008, Washington, DC, USA

The problem:

The development of a flexible framework for fast deploying of DDS scenarios

Presentation Outline

1. **Motivation of the problem**
2. Architectural overview
3. Modules
   - The Static Model
   - The Dynamic Model
   - The Commander
4. Scenario Deployment Example
5. Features and benefits summary
6. Future work

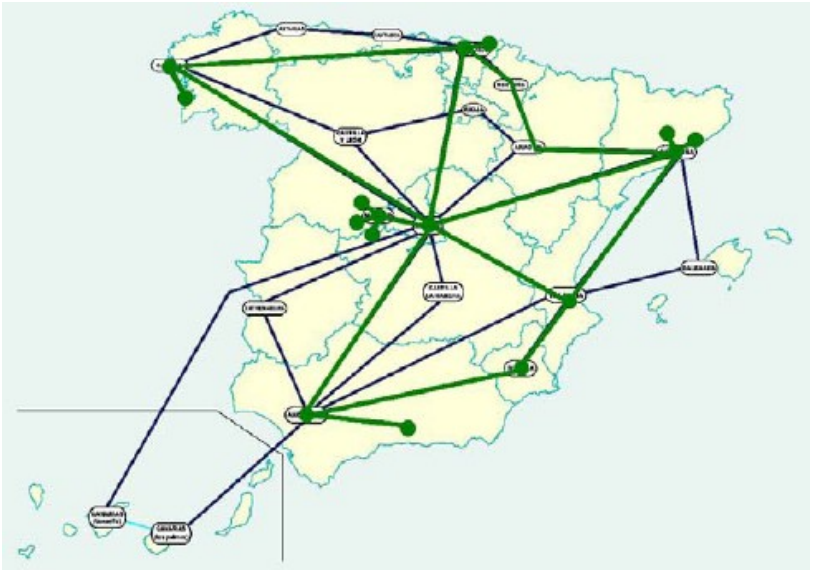
1. Motivation of the problem and goals

- Research group purpose
  - Leverage Spain's “Planet Lab”: PASITO
    - This is a inter-university project
    - WAN network, 15 sites in the start up
    - Support infrastructure for researches in networks and massive computing

1. Motivation of the problem and goals

- Distributed test scenarios issues and goals:
  - Stress Testing Scenario:

    "It involves testing beyond normal operational capacity, often to a breaking point, in order to observe the results"
  - DDS Stress Testing Scenario tasks:
    - Involves the creation of DDS applications with a **high number of entities distributed** across multiple nodes
    - Requires a way to establish **relationship** between these entities and associate test behaviors
    - **Coordinate and synchronize** the Life-cycle of large number of DDS entities



- **We need fast ways to prototype DDS systems!**

1. Motivation of the problem and goals

- Why use **XML** to prototype DDS systems?
  - Open, industry accepted standard
  - Ideal for setting up applications and representing knowledge
  - Supported by all common languages (C, C++, Java, C#...)
  - Easily editable and transformable:
    - By humans: text-based format
    - By XML specific tools or IDE such as Eclipse
  - Valid for describing DDS Entities parameters and DDS Entities relationship

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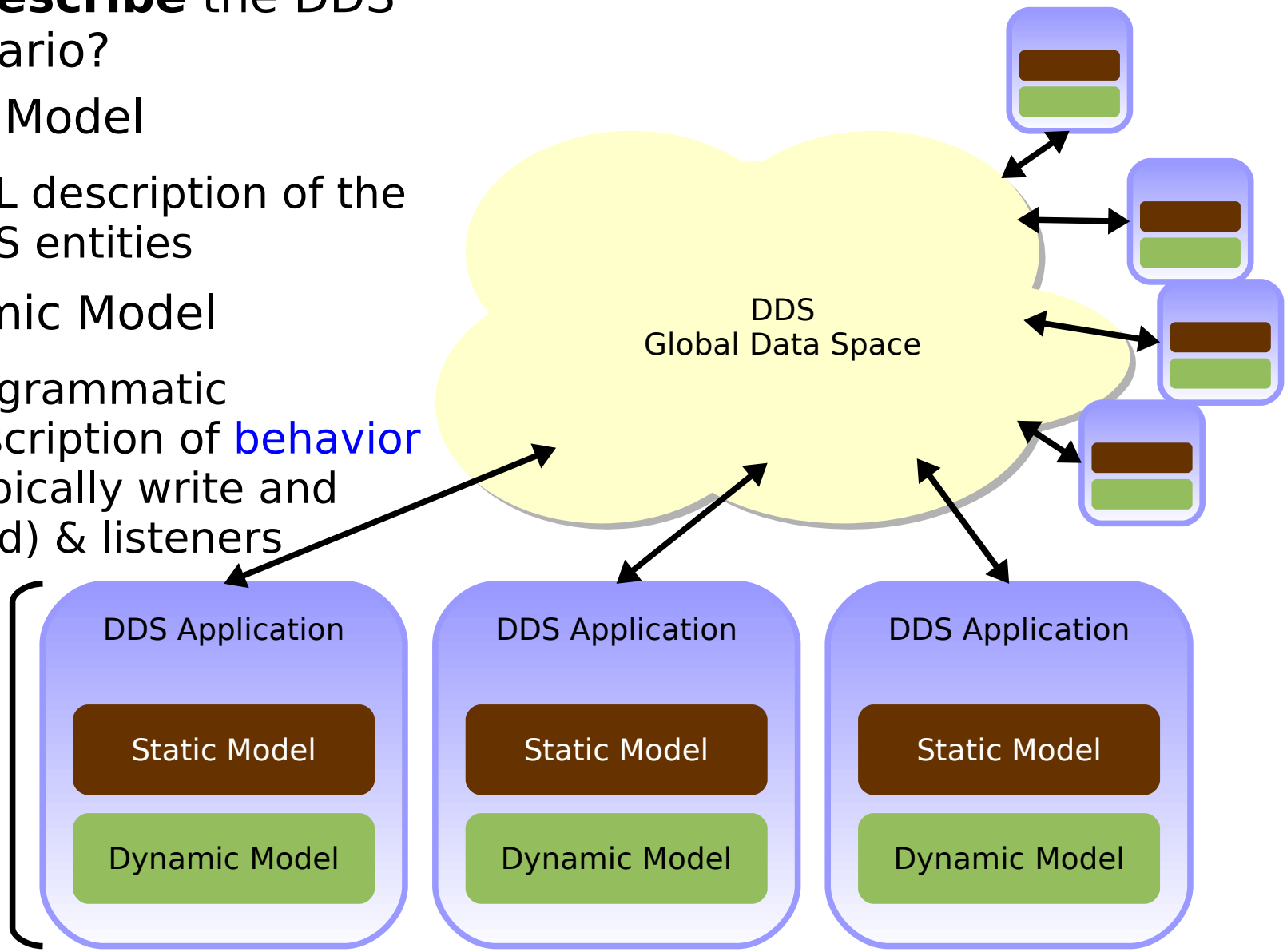
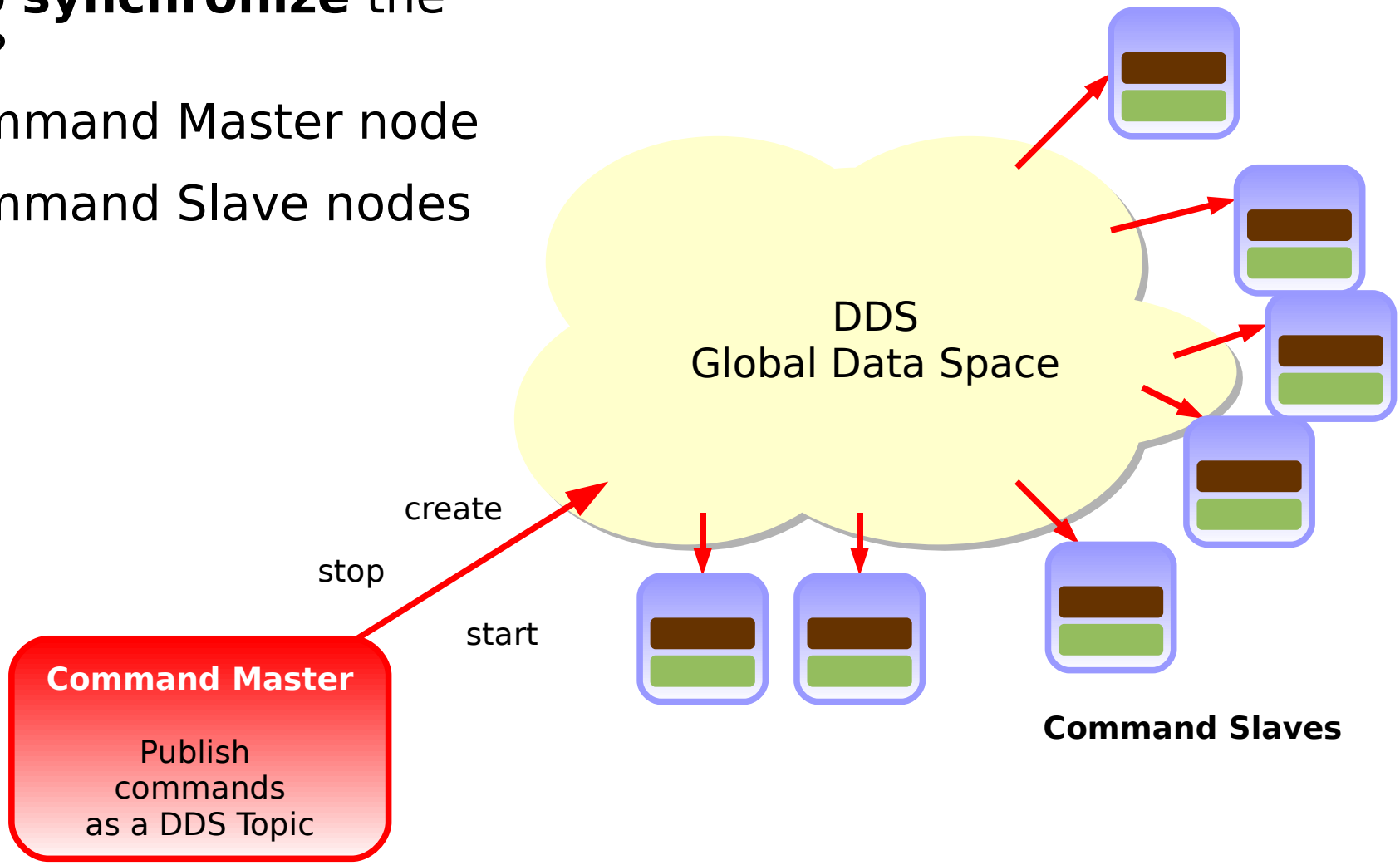
- How to **describe** the DDS test scenario?
  - Static Model
    - XML description of the DDS entities
  - Dynamic Model
    - Programmatic description of behavior (typically write and read) & listeners



- How to **synchronize** the nodes?
  - Command Master node
  - Command Slave nodes



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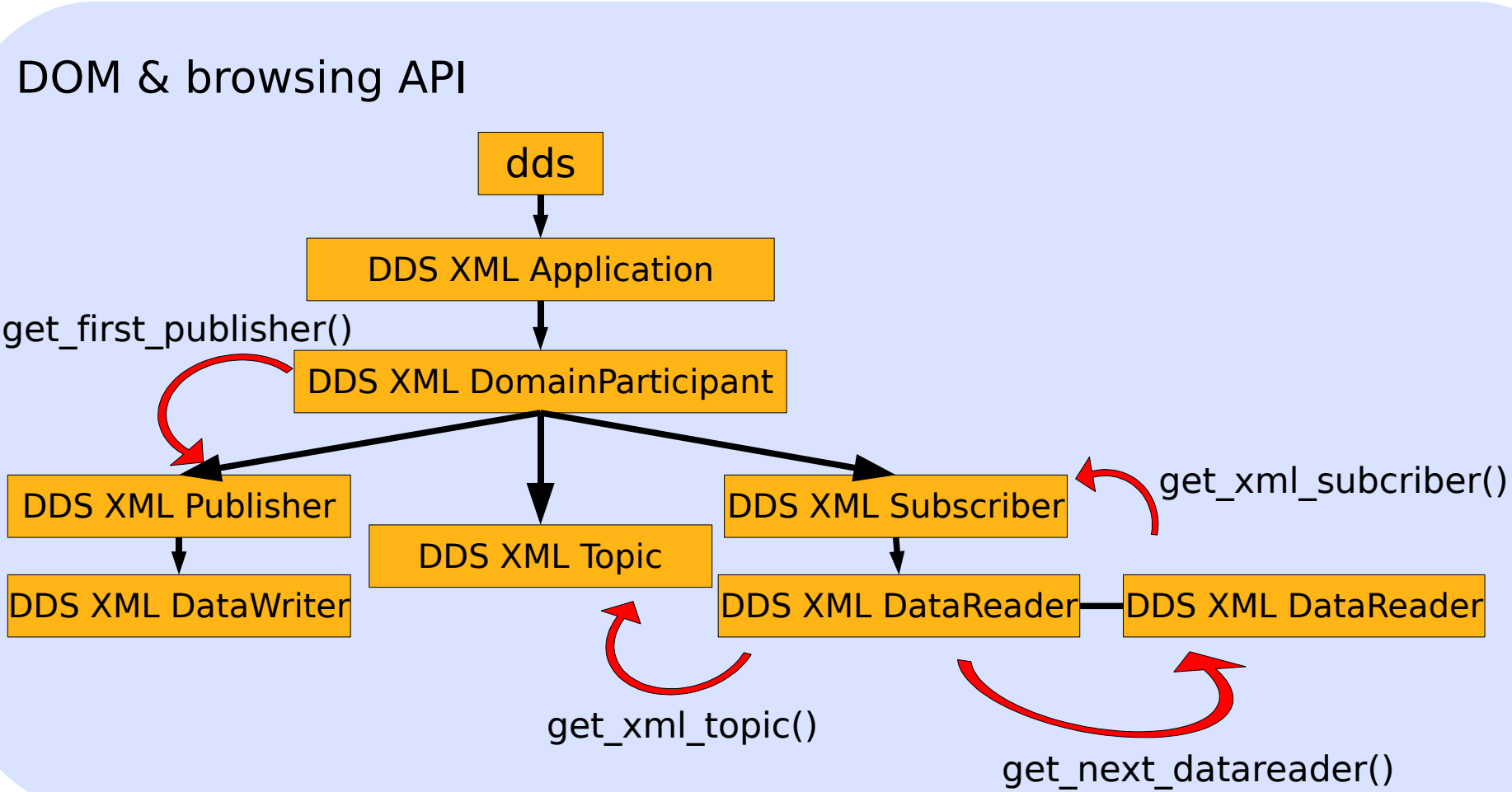
- Main modules of the framework
  - The **Static Model**:
    - Provides a way of describing DDS entities and the relationships between them
      - Information to set up the DDS Entities
      - Location of the DDS Entities
    - Allows the massive deployment of applications across the network nodes
  - The **Dynamic Model**:
    - Provides a way of writing a programmatic description of the activities of the entities
  - The **Commander**
    - Deals with nodes and entities synchronization

- **Static Model** components:
  - The XML Parser is built with Expat libraries
  - Document Type Definition (DTD), XML Schema (XSD) and Document Object Model (DOM)
  - The DOM is composed of a *specific objects set*
  - These objects are the **DDS XML Entities**:
    - **Manage information for creating DDS entities and set their behavior**
      - Stores DDS Entities data information: domain id, topic name...
      - A QoS profile name
        - We store a set of XML QoS profiles such as *default*, *LowLatency*, *MaximizeThroughput*...
      - Number of DDS entities to create
      - Behavior reference from the Dynamic Model
      - Listener reference and mask to apply
      - Thread's state information

- **Static Model** components:
  - DOM composed of DDS XML Entity Objects



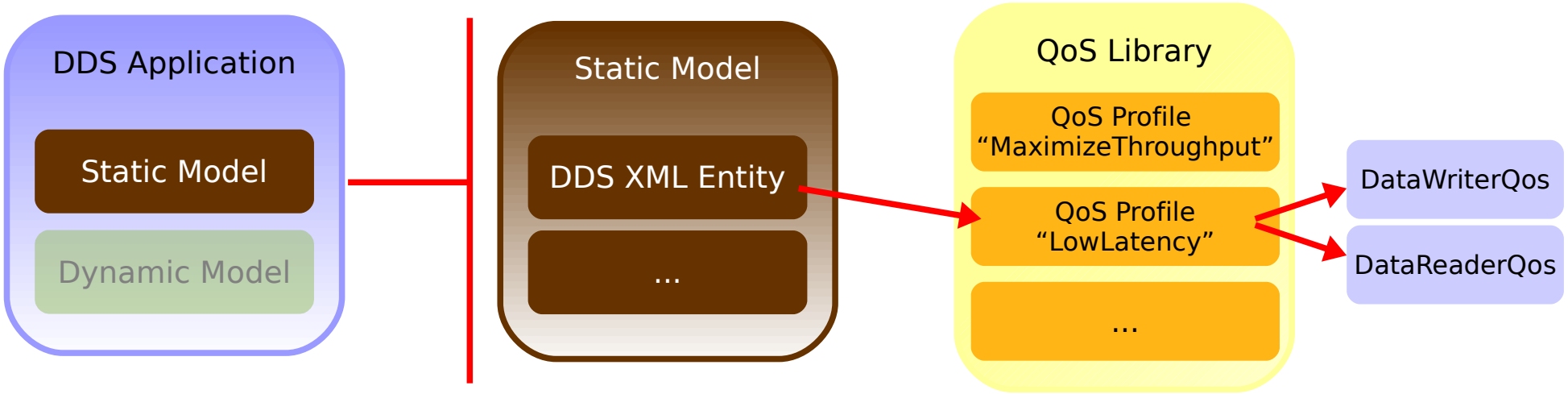
- Static description of the scenario: XML description of a DDS Application (QoS and Dynamic Model tags are omitted here):

```
<dds>
  <deployment>
   <node>
    <address>10.10.1.100</address>
    <application>hello</application>
   </node>
  </deployment>
  <application name="hello">
   <participant name="participant1">
    <domain_id>0</domain_id>
     <topic name="hello_world">
      <dds_name>Hello world</dds_name>
      <type>String</type>
     </topic>
     <publisher name="publisher1">
      <datawriter name="writer1a">
          <datawriter_topic>
              hello_world
          </datawriter_topic>
      </datawriter>
     </publisher>
   </participant>
  ...
 </application>
```

Deployment of the scenario based on roles, addresses

```
...
<subscriber name="subscriber1">
    <instances>2</instances>
    <datareader name="reader1">
     <datareader_topic>
         hello_world
     </datareader_topic>
     <instances>3</instances>
    </datareader>
   </subscriber>
 </participant>
...
```

- **DDS QoS Profiles**:
  - A QoS profile groups a set of related QoS, usually one per entity.
  - A QoS Library is a named set of QoS profiles.



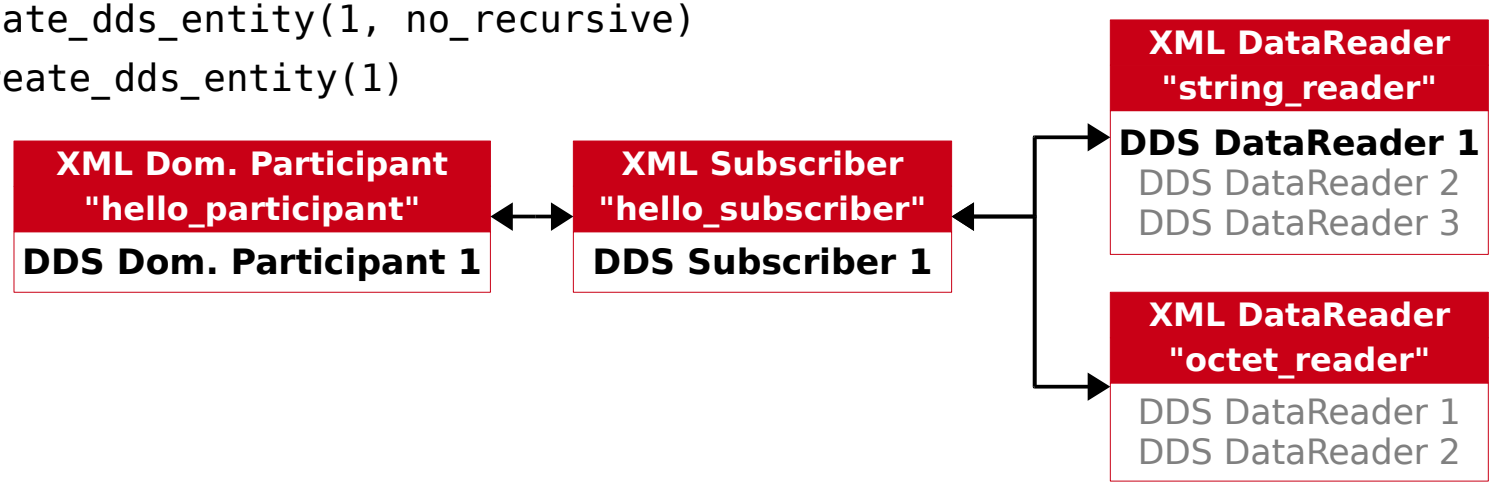

```
<qos_library name="MyTestLibrary">
  <writer_qos name="LowLatency">
   <history>
    <kind>
      DDS_KEEP_ALL_HISTORY_QOS
    </kind>
   </history>
  </writer_qos>
</qos_library>
```

3.1 Modules: the Static Model

- Static Model components: the **DDS XML Entities**
  - We provide a flexible **API** for managing a scenario Application
  - The set of DDS XML Entities provides an **API**:
    - wrap the DOM browsing API
    - get/set accessors methods (for retrieving & modifying the parsed data)
    - create & destroy DDS Entities instances
      - `xmlEntity.create_dds_entity(index, recursive)`
    - start & stop the entities behavior
      - `xmlEntity.start_behavior(index, recursive)`
  - *index* refers to a DDS instance number inside the DDS XML Entity
  - *recursive* allows to call to all the children's create, destroy, start & stop methods

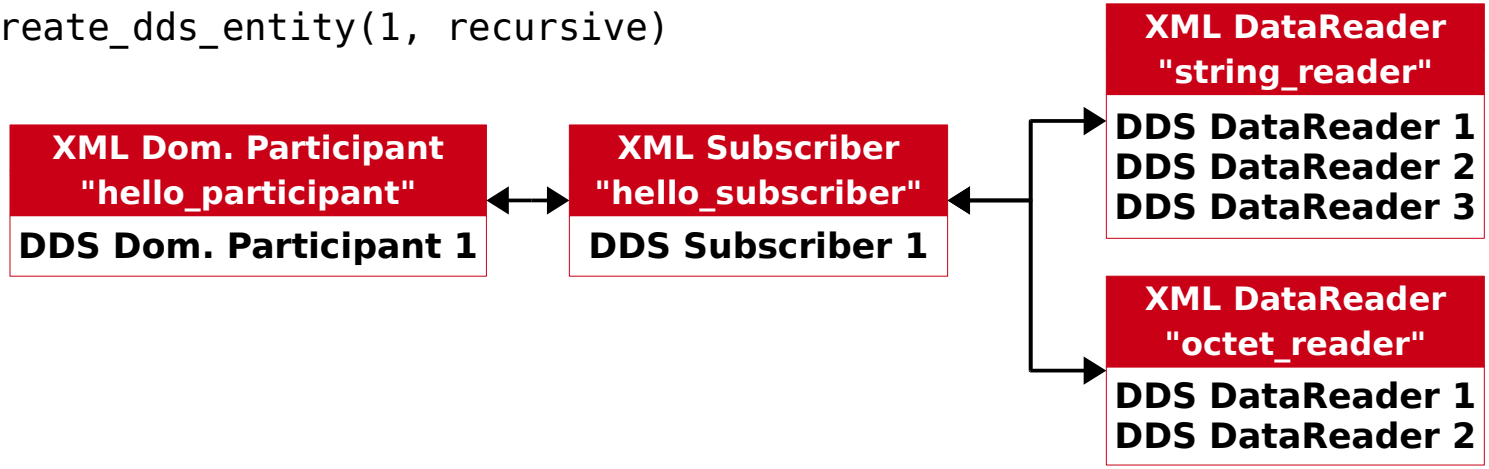
- Create a subset of DDS Entities:

```
xmlParticipant.create_dds_entity(1, no_recursive)
xmlPublisher.create_dds_entity(1, no_recursive)
xmlDataReader.create_dds_entity(1)
```



- Create all DDS Entities:

```
xmlParticipant.create_dds_entity(1, recursive)
```



3.2 Modules: the Dynamic Model

- The **Dynamic Model** describes the behavior of the DDS entities that compose the Static Model
- This description is done by programming a behavior method and configuring entity listeners
  - Minimum DDS API knowledge is required
- The **Dynamic Model** module provides
  - A set of built-in behavior functions, listeners and data type support
  - API for retrieving the methods and listeners
- The user needs to include his methods and listeners into the Dynamic Model

3.2 Modules: the Dynamic Model

- How to **connect** the user Dynamic Model with the Static Model:
  - The Dynamic Model is a shared library
  - The user should specify where to look for the Dynamic Model

```
<datawriter name="writer1a">
 <datawriter_topic>hello_world</datawriter_topic>
 <behavior>
   <shared_library>mylibrary.so</shared_library>
   <function_name>write_helloloop</function_name>
   <user_data>200</user_data> <!-- write period -->
 </behavior>
</datawriter>
<datareader name="reader1">
  <datareader_topic>
      hello_world
  </datareader_topic>
  <instances>3</instances>
   <behavior>
     <shared_library>mylibrary.so</shared_library>
     <listener>
       <listener_data>....</listener_data>
       <on_data_avaliable>on_data_available</on_data_available>
     </listener>
   <behavior>
</datareader>
```

3.3 Modules: the Commander

- The **coordination** of the scenario is done by using DDS itself
- It is composed of two DDS based classes:
  - CommandPublisher
  - CommandSubscriber
- The test framework provides DDS tools to the user:
  - *cmdmaster*: uses the a CommandPublisher instance to publish commands
    - Command line tool
    - Simple authentication via built-in phrase pass
    - Command Topic configured with QoS Owned, reliable...
  - *cmdslave*: uses a CommandSubscriber instance to get and process commands
    - Each node in the scenario must load this application
- Theses classes uses the Static and Dynamic Models API for **deploying** the test scenario

- Current user's **Commands set**:
  - Commands can be applied to concrete entities
  - Load of the scenario XML file:
    - By specifying it as a command line argument to the DDS applications for each of the nodes
    - By publishing it to the nodes

Comand	Example
`load <xml filename>`	`load "scenario.xml"` `load "url://.../scenario.xml`
`create <xml_entity_id> <dds_instance_number>`	`create "mydatawriter" 2`
`createall`	`createall`
`destroy <xml_entity_id> <dds_instance_number>`	`destroy "mydatawriter" 2`
`destroyall`	`destroyall`
`start <xml_entity_id> <dds_instance_number>`	`start "mydatawriter" 2`
`startall`	`startall`
`stop <xml_entity_id> <dds_instance_number>`	`stop "mydatawriter" 2`
`stopall`	`stopall`
`terminate`	`terminate`

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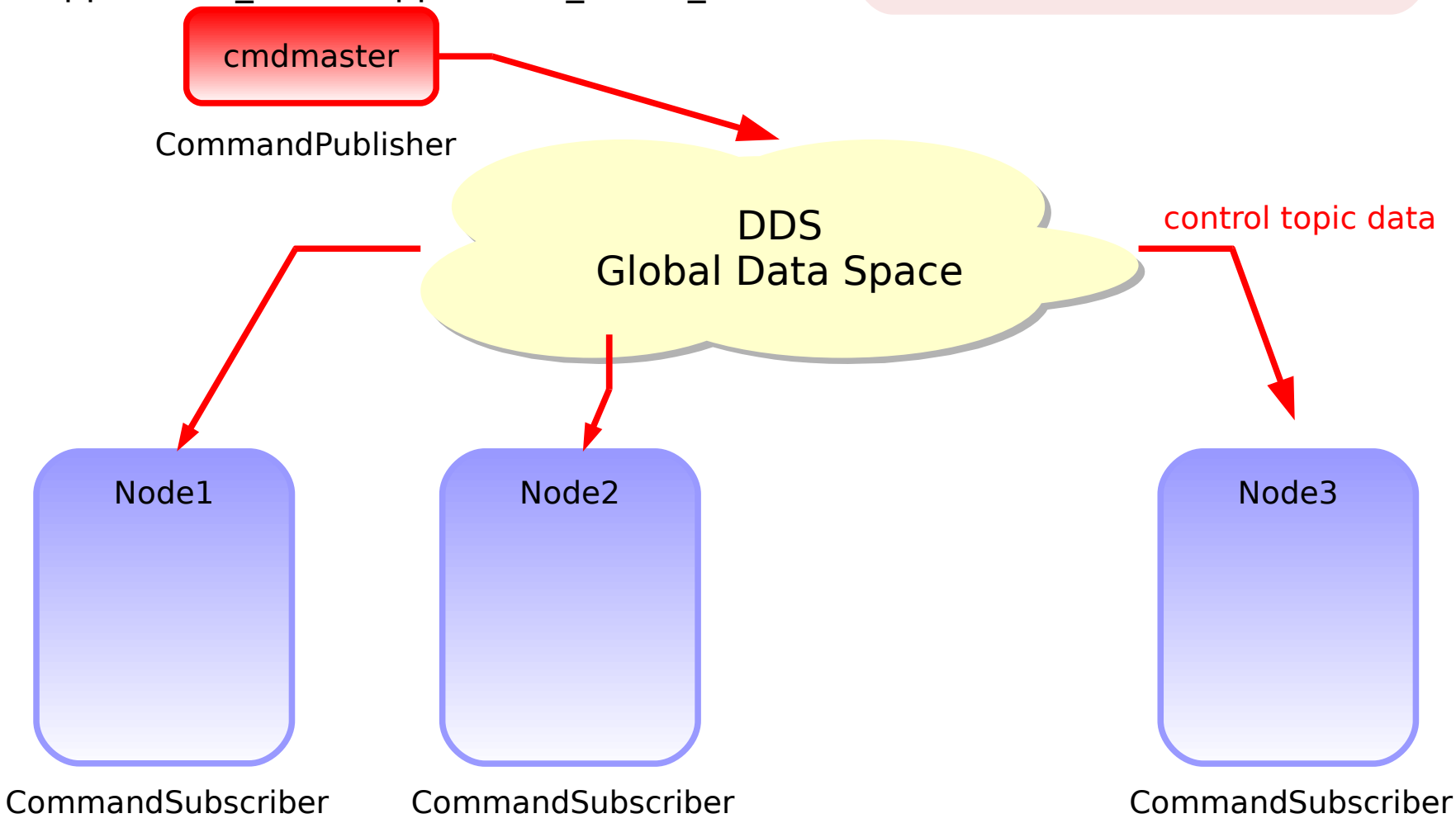
4. Scenario Deployment Example (I)

- The scenario is ready with *cmdmaster* and *cmdslave* running in the proper nodes
- scenario.xml has two DDS applications
  - Application_radar, Application_traffic_control

Control Topic:

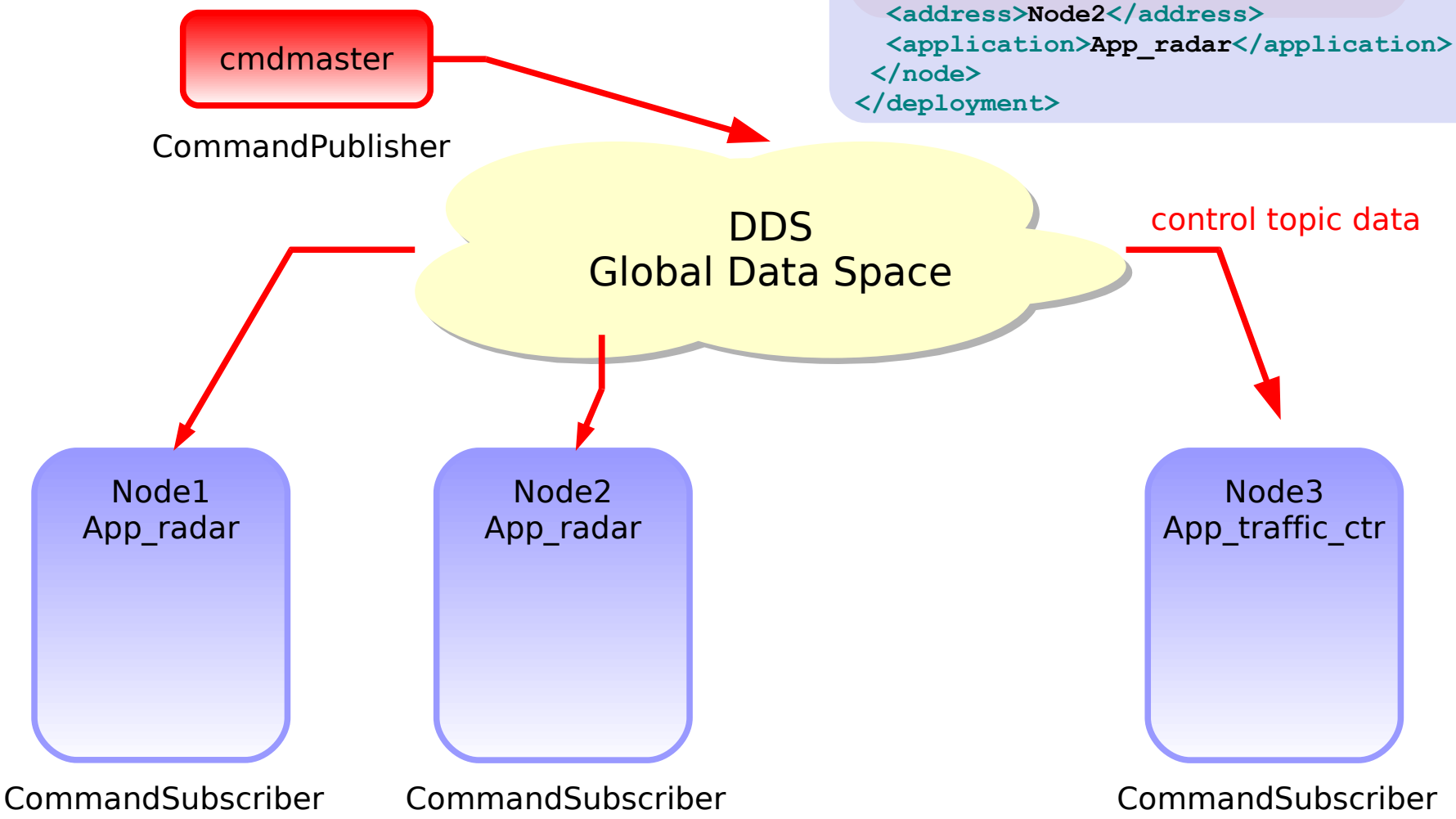


4. Scenario Deployment Example (II)

- Distribute the XML scenario across the nodes.
- The nodes will automatically select the application based on the deployment tag

Control Topic:
>load "scenario.xml"

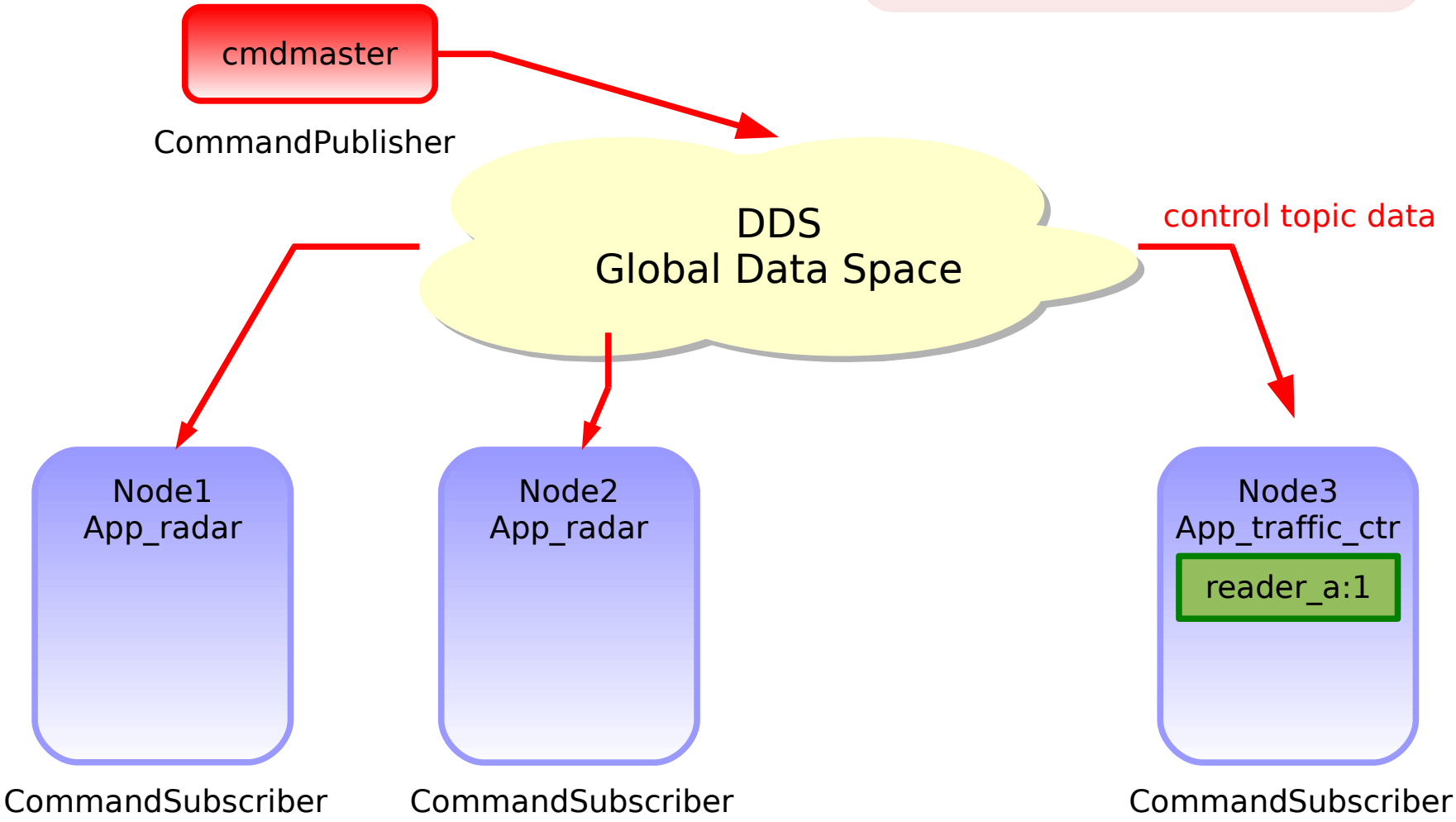
```
<deployment>
 <node>
  <address>Node1</address>
  <address>Node2</address>
  <application>App_radar</application>
 </node>
</deployment>
```



4. Scenario Deployment Example (III)

- Create Participants, Topics, Publishers and Subscribers
- Create instance 1 of DataReader "reader_a"

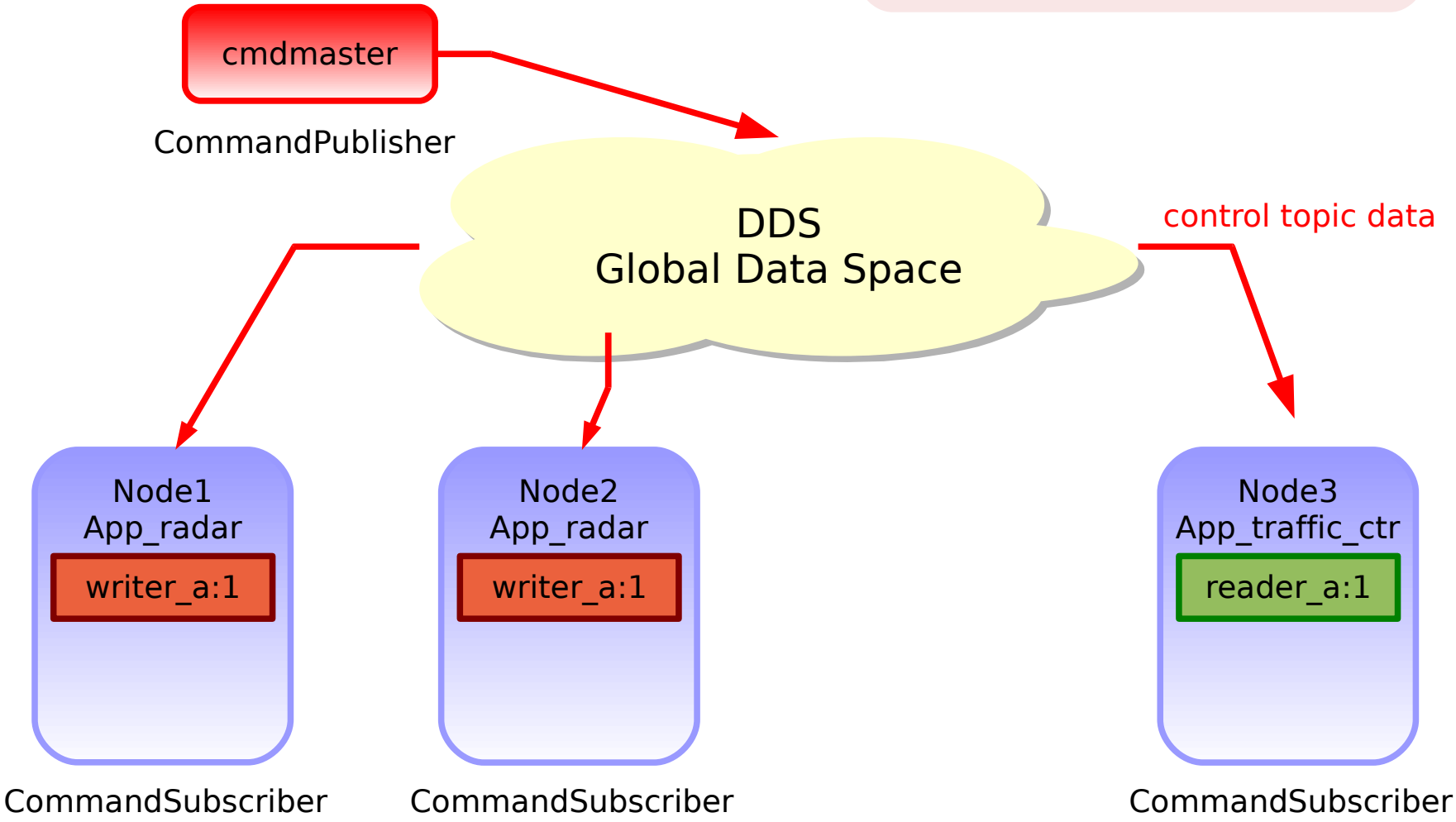
Control Topic:
>create participants
with participant's childs
>create “reader_a" 1



4. Scenario Deployment Example (IV)

- Create instance 1 for all DataWriters with name "writer_a”
- Up to this point, we can measure, for example, discovery time

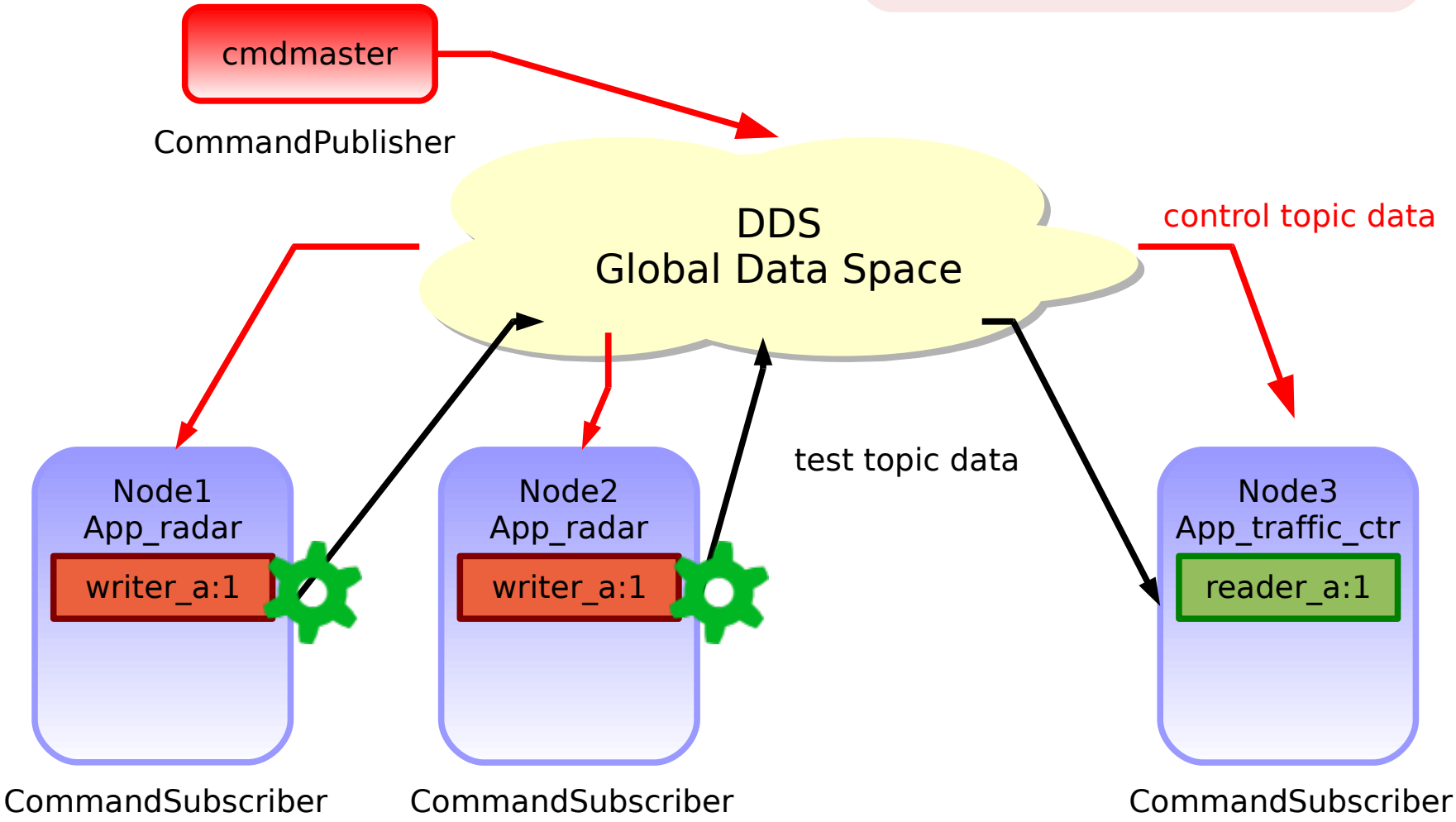
Control Topic:
>create “writer_a” 1



4. Scenario Deployment Example (V)

- Start the behavior of some DataWriters
  - Typically, this is writing data

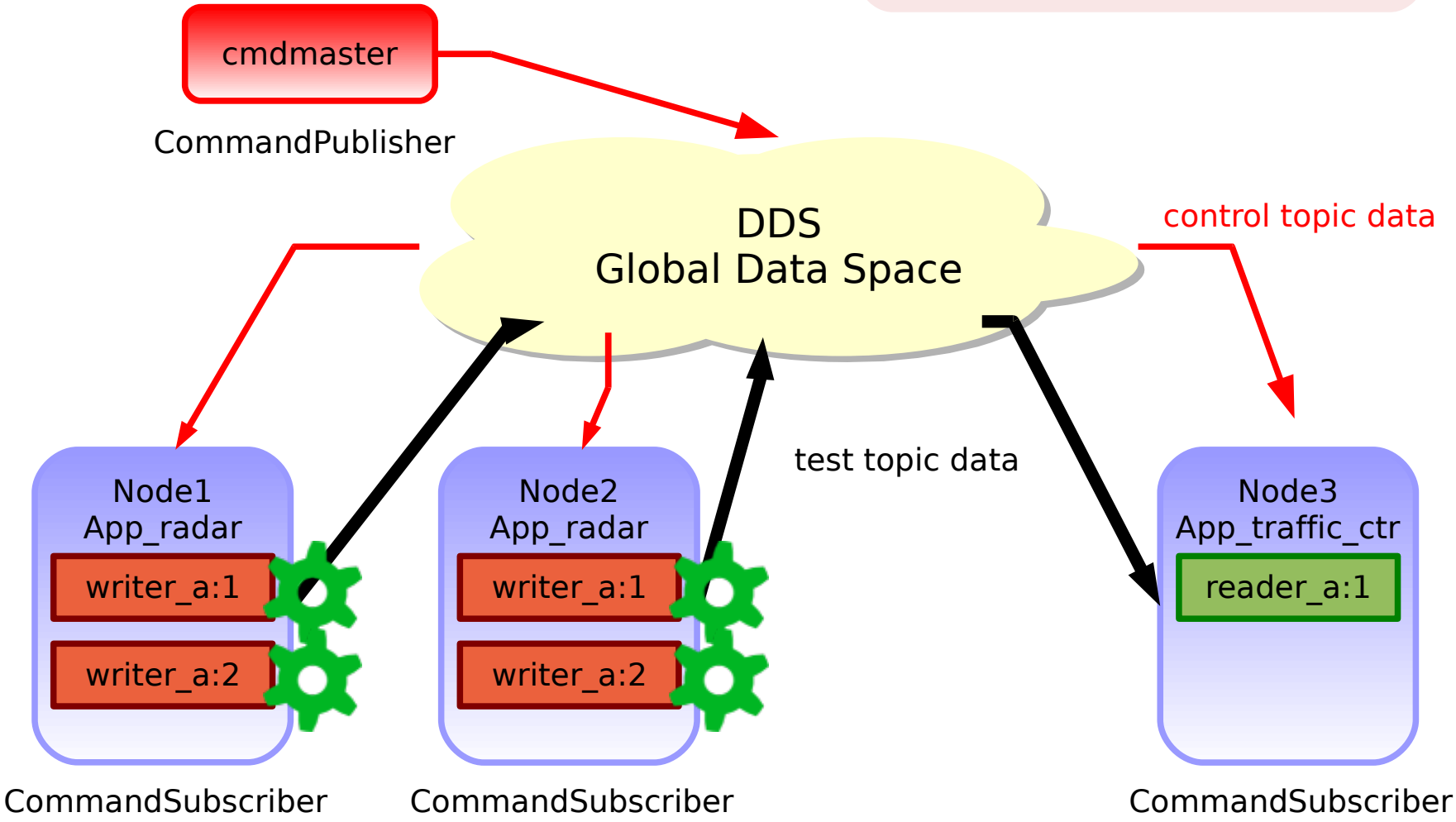
Control Topic:
>start “writer_a” 1



4. Scenario Deployment Example (VI)

- Create more entities and start their behavior

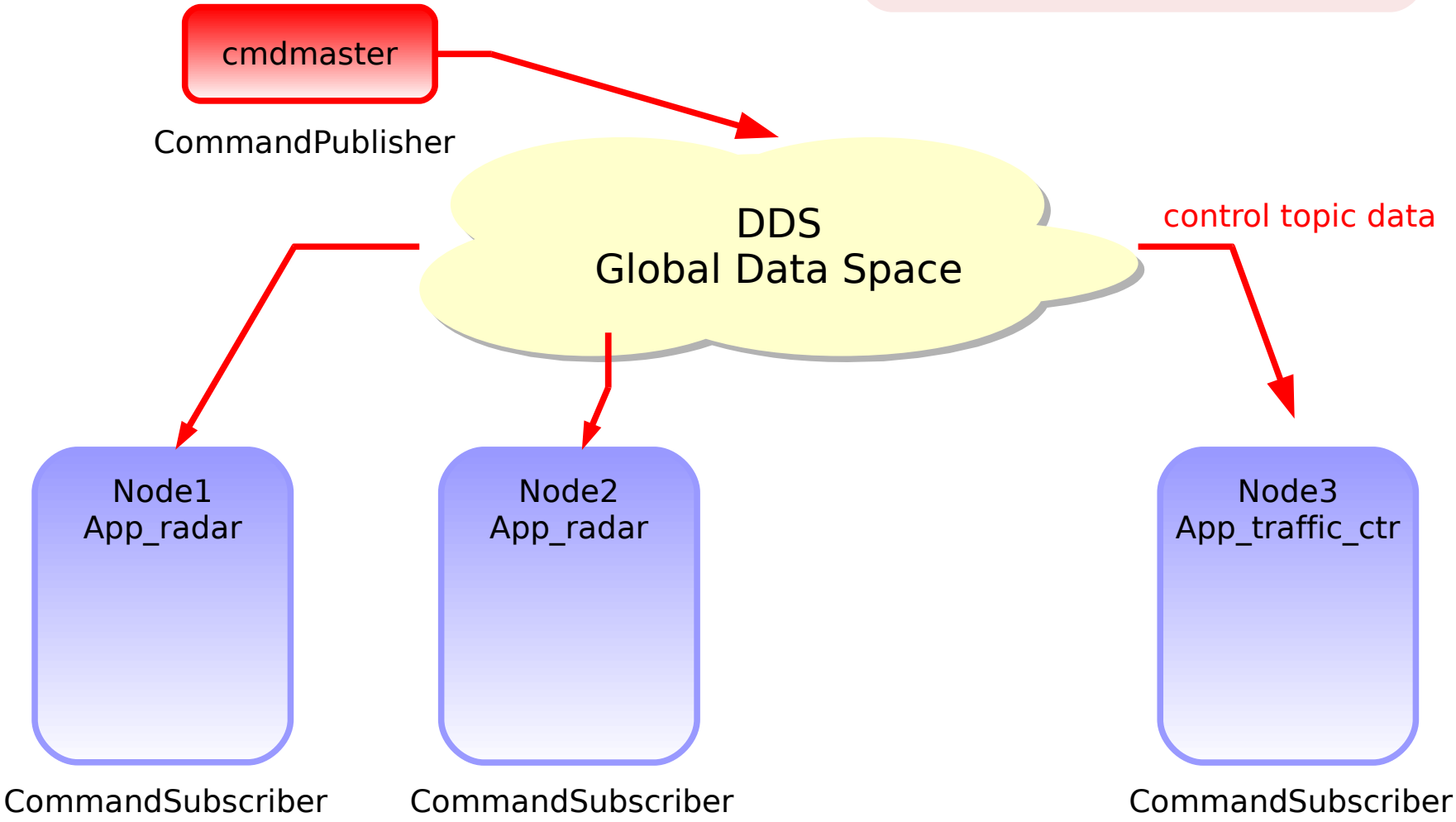
Control Topic:
>create “writer_a” 2
>start “writer_a” 2



4. Scenario Deployment Example (VII)

- Stop all the entities and destroy them

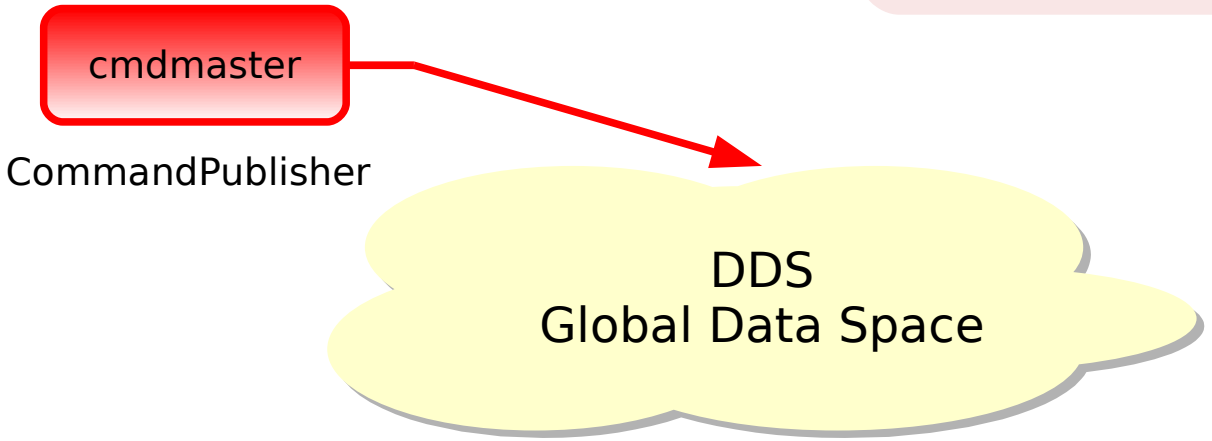
Control Topic:
>stopall
>destroyall



4. Scenario Deployment Example (VIII)

- Terminate the *cmdslaves*

Control Topic:
>terminate



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5. Features and benefits summary (I)

- Division between static and dynamic model allows:
  - Reducing user's source code.
- The flexibility of the framework API and commands design permits:
  - Measuring DDS entities creation and discovery times
  - Performing gradual increase of network load and nodes activity
- The XML description allows:
  - To control if every node can “see” all the other entities in the scenario.
    - Each node can collect discovery information and compare it with the XML scenario description it has
  - To change the DDS entities configuration, number of instances and behavior by modifying a few XML lines in a file

5. Features and benefits summary (II)

- The Commander module allows:
  - To distribute the scenario description by using DDS itself:
    - We don't need to worry about XML files synchronization
      - We do not depend on SSH or NFS to synchronize resources
      - We can deploy on a Wide Area Network
    - We can use our test tool for testing any platform supported by a DDS product, even if the platform does not support a file system
- At the end, we are creating a fast-prototype tool for DDS applications
  - Allows testing any kind of scenarios before starting the real DDS application deployment
    - The user only needs to program some methods for integrating the prototype into his system.
- We can reuse this platform for synchronize non DDS applications execution in distributed environments

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6. Future work

- Establish a full plugin API for loading the Dynamic Model
- Extend the XML model:
  - Allow XML user types definition
  - Support full DDS features:
    - Network transports
    - Discovery peers
    - ...
- Improve authentication module for Command Topic
- Define a statistics generation Dynamic Model
- Add a GUI scenario visualization tool
- Feedback from the experience in Spanish's planet lab *PASITO*

Acknowledgments

Thank you very much!

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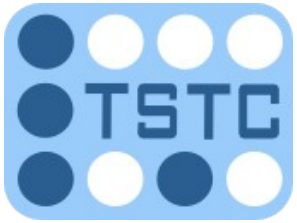

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