Robot Operating Systems 2

Lecture 1: Middleware Fundamentals

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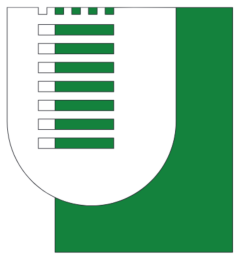
Month Day, Year



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Roadmap

Roadmap

What is middleware?

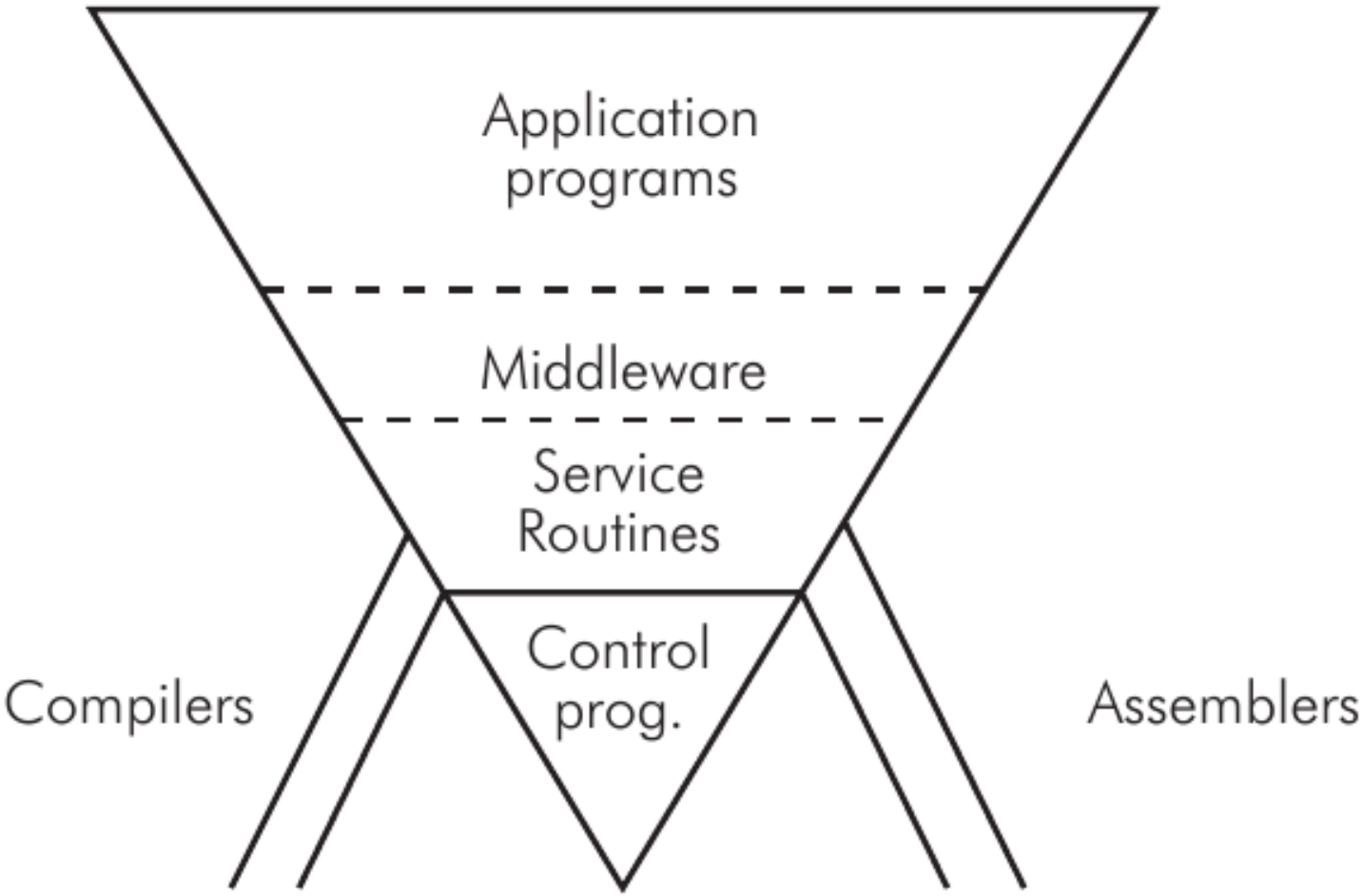

Figure 1: Software organization in a generic computer system

What is middleware?

Definition of middleware

The term **middleware** identifies a kind of software that offers common services and functionalities to applications in addition to what an operating system usually does.

Middlewares are usually implemented as **libraries** that application programmers can use via appropriate **APIs**.

Middleware in robotics

Classic problems arising when developing software for autonomous systems:

- definition of tasks;
- hardware integration;
- software organization and maintenance;
- communication and data exchange (involves both hardware and software!);
- debugging and testing.

Middlewares can offer services to tackle and solve each one!

Data Distribution Service

Definition of DDS

A DDS is a **publish-subscribe middleware** that handles communications between **real-time** systems and software over the network.

DDS implementations follow an open standard that defines:

- serialization and deserialization of data packets;
- automatic discovery of **DDS participants** (over **multicast-IP/UDP**) and transmission of data (over **unicast-IP/UDP**);
- **security protocols** and cryptographic operations;
- enforcing of **Quality of Service** policies to organize transmissions (specifying things like **queue sizes**, **best-effort** or **reliable** transmissions...).

DDSs are currently used in automotive, aerospace, military...

Data Distribution Service

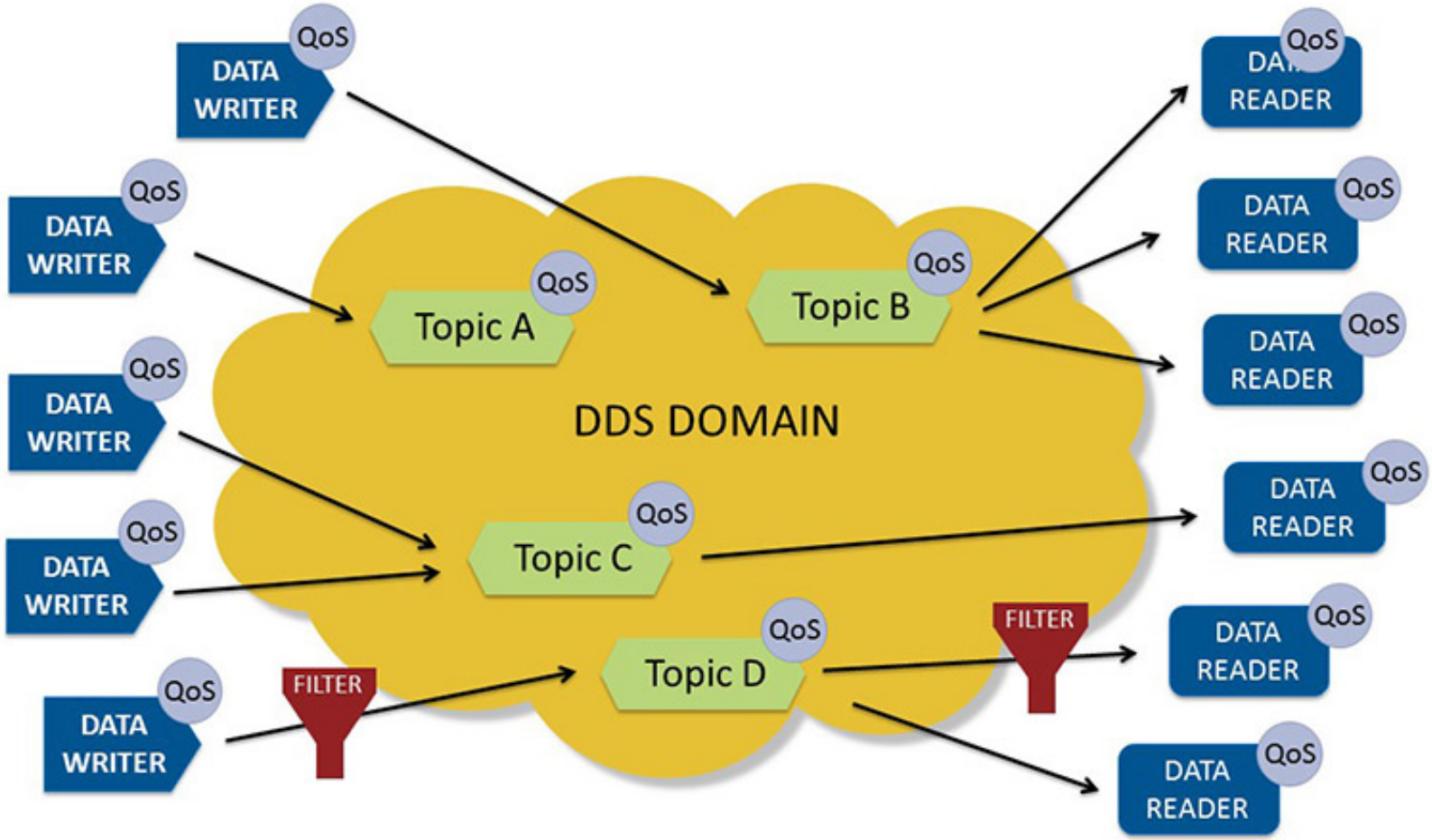

Figure 2: Scheme of a DDS-based network

Data Distribution Service

DDS participants can either **publish to** or **subscribe to** a **topic**.

Definition of DDS topic

A DDS topic is uniquely identified by three things:

- a **name**, i.e. a human-readable character string;
- an **interface**, i.e. a custom packet format that specifies what data is carried over it (e.g. strings, numbers, arrays...);
- a **QoS policy** that specifies how transmissions should be performed.

Changing even only one of the above results in a completely different topic!

Roadmap

What is ROS 2?

ROS 2 is a **DDS-based**, **open-source** middleware for robotic applications. It allows developers to build and manage **distributed control architectures** made of many modules, usually referred to as **nodes**.

Figure 3: ROS 2 logo

What is ROS 2?

ROS 2 currently supports **C++** and **Python** for application programming, and runs natively on **Ubuntu Linux 20.04**.

New versions are periodically released as **distributions**: the current LTS one is **Foxy Fitzroy** and the latest one today is **Galactic Geochelone**; the development version is **Rolling Ridley** and can only be compiled from source.

Figure 3: ROS 2 logo

Main Features

As a middleware, it offers the following services to roboticists:

- **three inter-process communication (IPC) paradigms**, easy to set up and based on the DDS;
- organization of software packages, allowing for **redistribution and code reuse**, thanks to the **colcon** package manager;
- module configuration tools: **node parameters** and **launch files**;
- integrated **logging subsystem** (involves both console and log files);
- CLI **introspection tools** for debugging and testing;
- integration with **simulators** (e.g. Gazebo) and **data visualizers** (e.g. RViz);

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- CLI **introspection tools** for debugging and testing;
- integration with **simulators** (e.g. Gazebo) and **data visualizers** (e.g. RViz);
- and much more...

Flaws

ROS 2 biggest flaws (as of today)

The main concerns arise when developing low-level stuff:

- the DDS layer is almost completely abstracted, so some network configurations are impossible;
- the internal job scheduling algorithm (the **executor**) is **not suited for hard real-time applications**.

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What to do when development gets to a really low level?

- Use **micro-ROS**: ROS 2 on microcontrollers and different communication interfaces.
- Hand off stuff to **microcontrollers**.
- Use something else.

Job Executor

TODO:

- event-based explanation
- node jobs+executor+callback scheme
- "to be addressed in new upcoming releases+micro-ROS"

Roadmap

Frame Name

Frame contents