

# Robot-Robot Communication

## Which standards & software can help?

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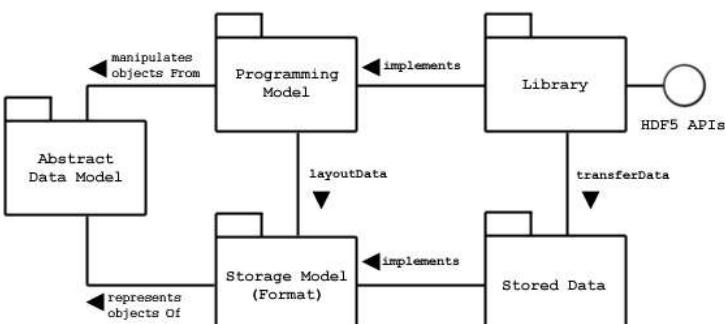
## Objectives

To introduce some relevant standards and software for “multi-vendor” systems-of-systems integration:

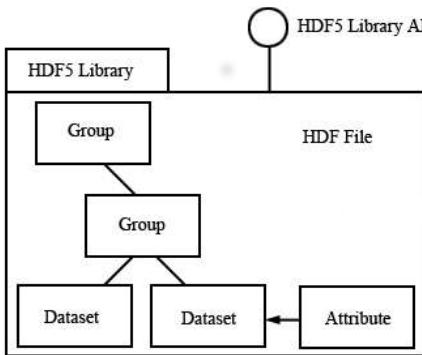
- ▶ **HDF5**: <http://www.hdfgroup.org>
  - ▶ complex binary data structures
  - ▶ meta data attributes
- ▶ **ØMQ**: <http://zguide.zeromq.org>
  - ▶ message passing
  - ▶ large set of communication protocols
- ▶ **iRODS**: <https://www.irods.org>
  - ▶ distributed, federated “big data” storage for logging
  - ▶ meta data can be queried
  - ▶ “big data” can be selectively retrieved

## HDF5

The Hierarchical Data Format (HDF) implements a model for managing and storing data. The model includes an abstract **data model** and an abstract **storage model** (the data format), and libraries to implement the abstract model and to map the storage model to different storage mechanisms.

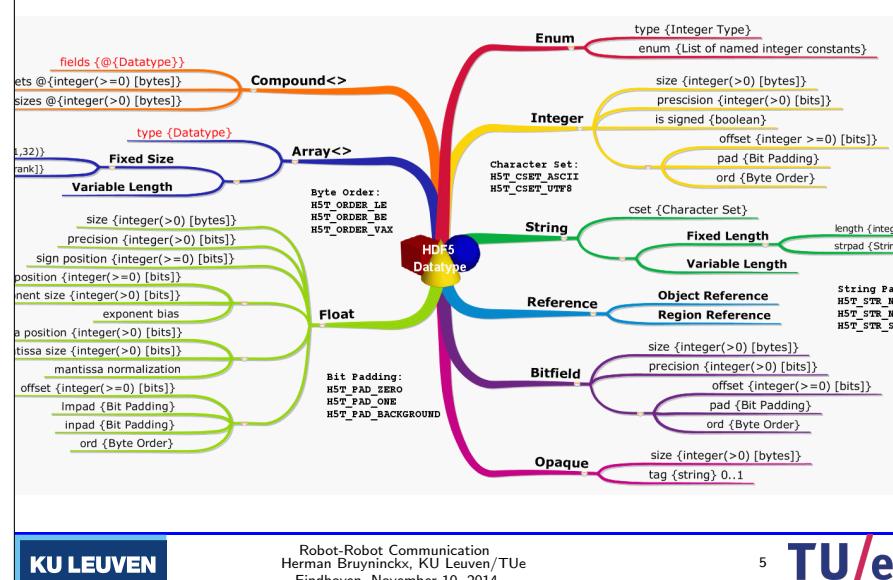


## HDF5 data model

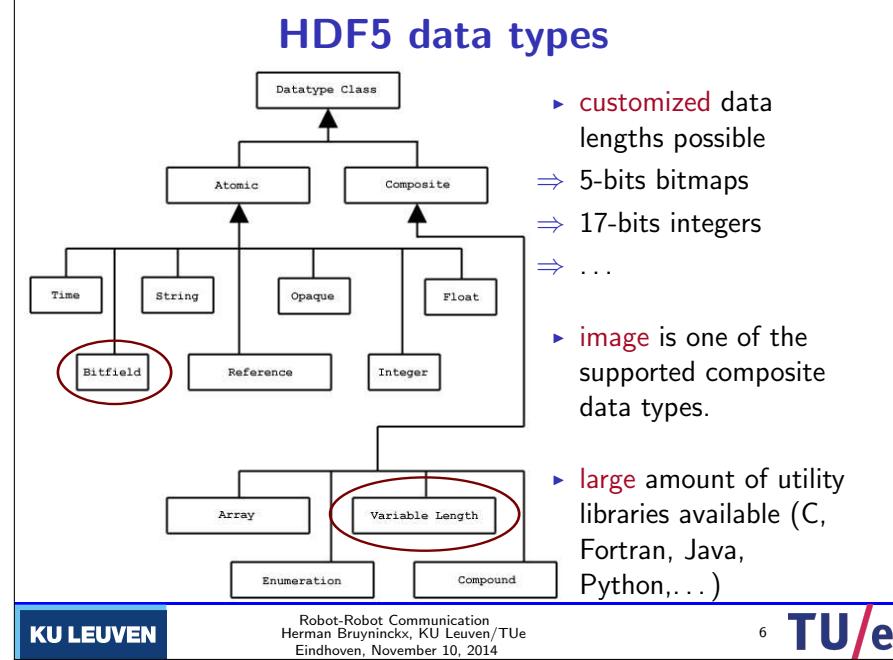


- ▶ *File*: contiguous string of bytes in computer store ([memory](#), disk, etc.)
- ▶ *Group*: collection of objects
- ▶ *Dataset*: multidimensional array of data elements with attributes and other metadata
- ▶ *Dataspace*: description of dimensions of multidimensional array
- ▶ *Datatype*: description of a specific class of data element including its storage layout as a pattern of bits
- ▶ *Attribute*: named data value of group, dataset, or named datatype
- ▶ *Property List*: options in the library
- ▶ *Link*: the way objects are connected

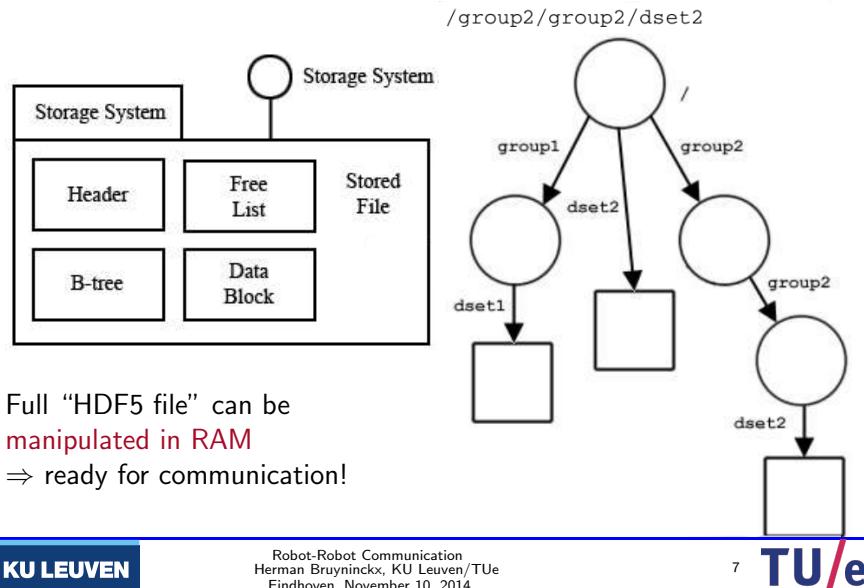
## HDF5 data model (2)



## HDF5 data types



## HDF5 storage model

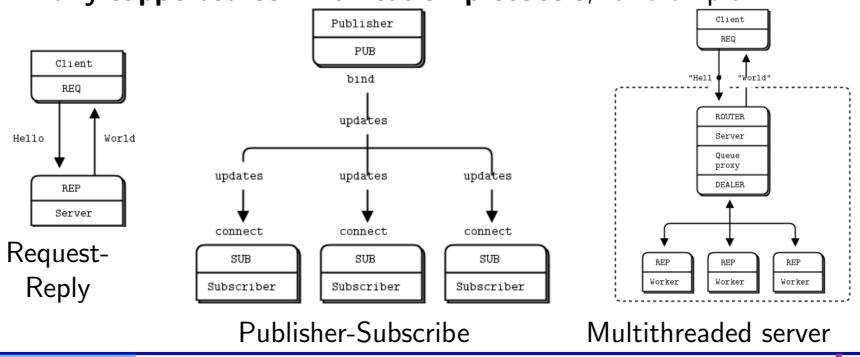


## ØMQ

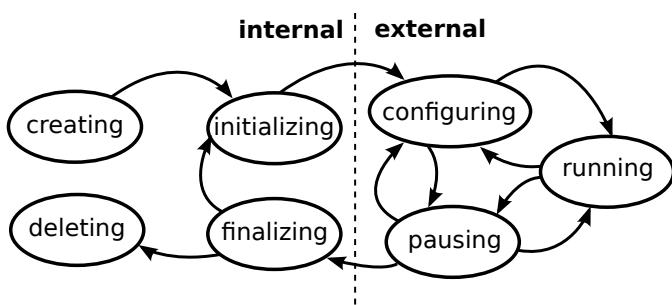
### "Socket"-based communication:

- in-process, inter-language, IPC, inter computer,...
- bindings & reference implementation in more than 30 languages.

### Many supported communication protocols, for example:



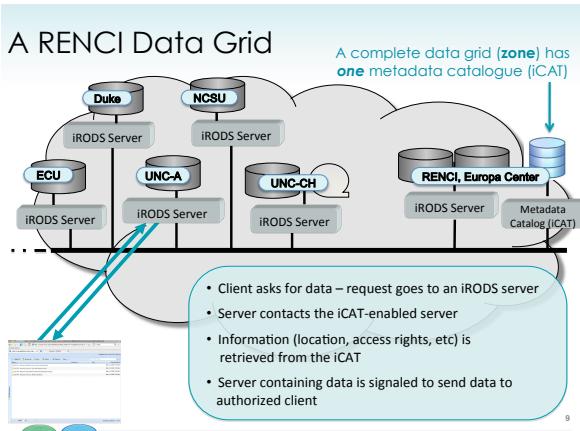
## ØMQ: Life Cycle State Machine



### Important for:

- synchronising start-up, pausing, shutting down of distributed systems.
- similarly, synchronising of tasks.

# iRODS



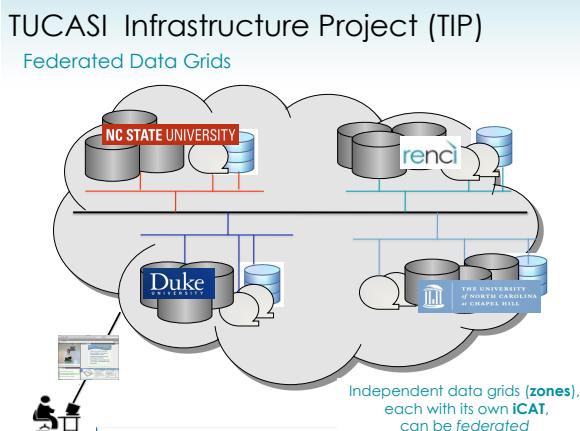
[www.irods.org/index.php/Database\\_Resources](http://www.irods.org/index.php/Database_Resources)

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## iRODS server federation



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## Conclusions

- ▶ “**multi-vendor**” requires **standardization**
- ▶ in particular of the **meta data!**
- ▶ **large-scale integration** requires **professionally supported libraries, frameworks, servers,...**
- ▶ **lots** of stuff exists already outside of the robotics domain
- ▶ with strong **separation of concerns**: modelling, message passing, interaction/synchronisation protocols, sensor fusion, logging, querying,...
- ▶ **international foundation** to coordinate robotics software development & integration would be very welcome... !

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