Evolution of the EPICS Channel Access Protocol

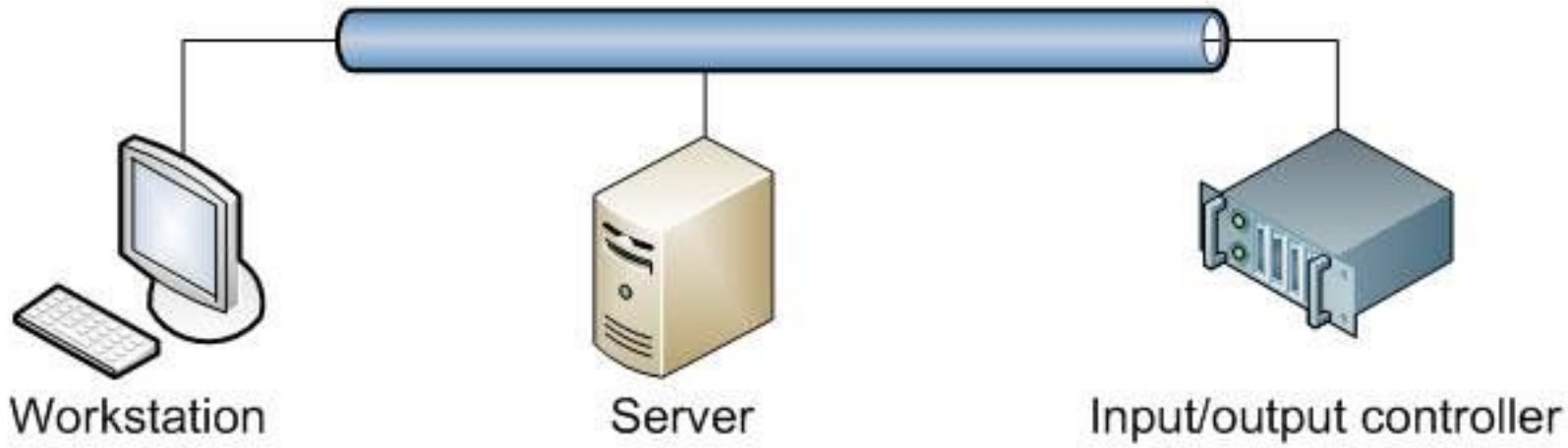
Klemen Žagar <klemen.zagar@cosylab.com>
Matej Sekoranja
Marty Kraimer
Bob Dalesio

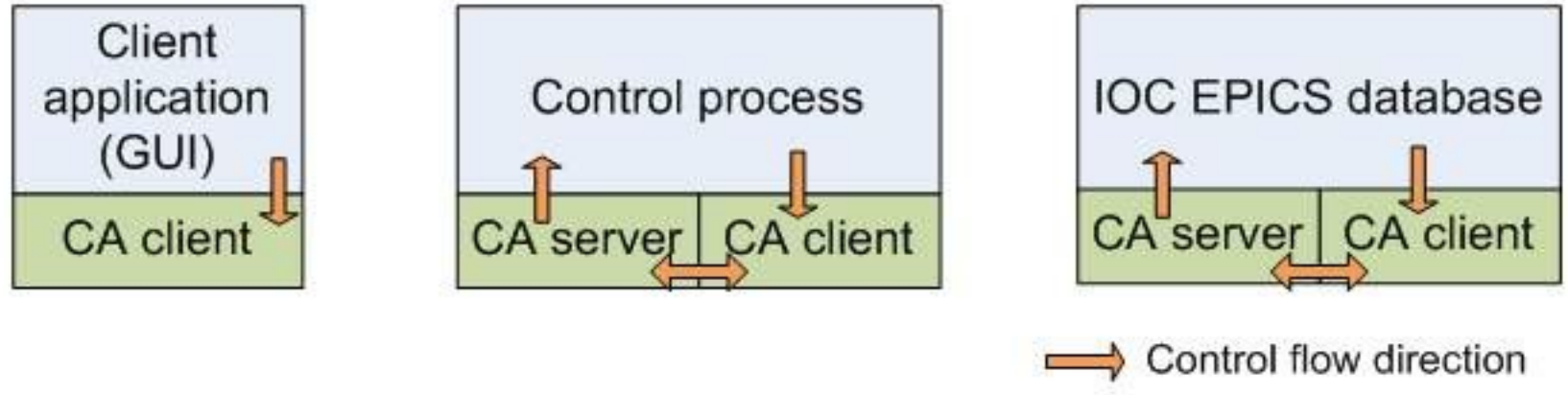
Overview

- The role of the EPICS Channel Access (CA) protocol
- What is new in EPICSv4's CA?
  - Clean design with few dependencies
  - Asynchronous API and design
  - Support for structured process variable (PV) data – pvData
  - Connecting to several fields of a pvData structure
  - Client-specified filters
  - Flow control for monitors
  - Remote procedure calls
- Plans
- Conclusion

The role of the EPICS Channel Access (CA) protocol

- Enables communication between EPICS clients, input/output controllers and other nodes.





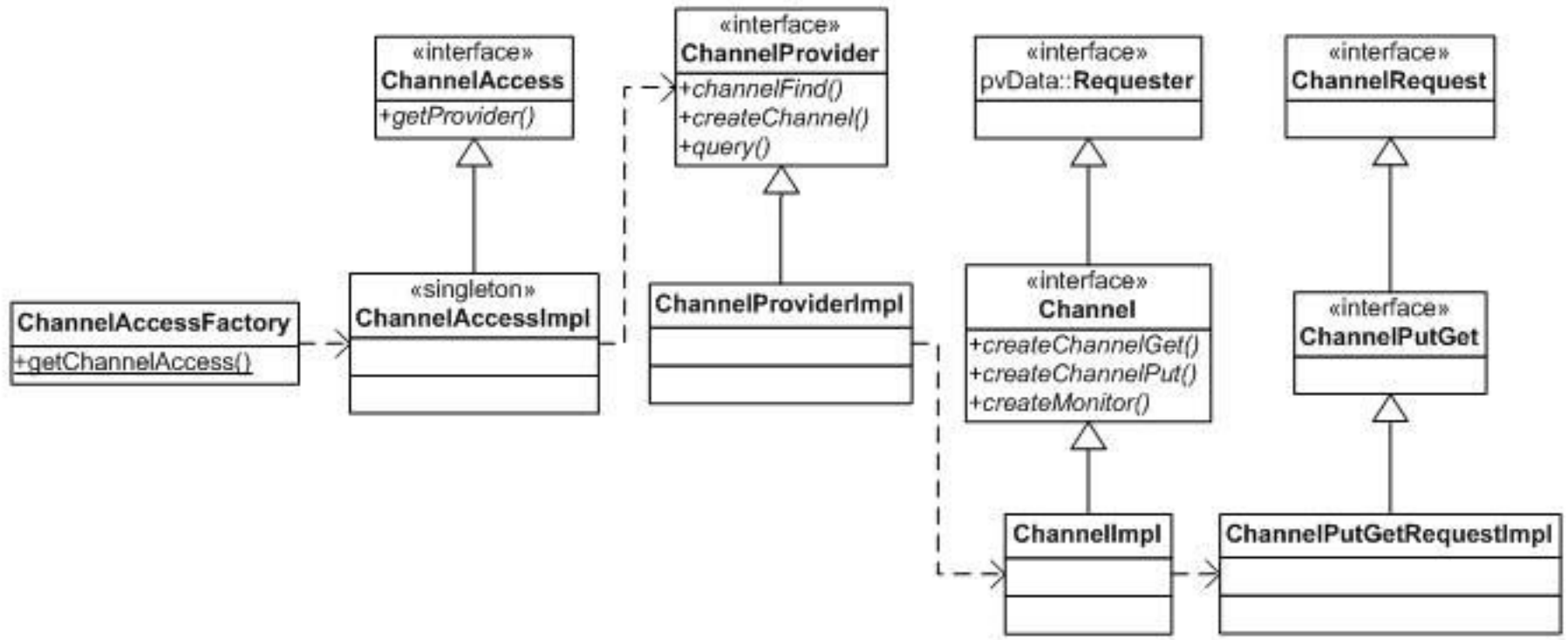
Client requests data, **server** provides data.

- **Record**: an addressable, self-consistent unit of data. E.g., represents a process variable. Consists of **fields** (e.g., value, alarm status, etc.).
- **Channel**:
  - (Virtual) connection between client and server.
  - System-wide unique name.

WHAT IS NEW FOR EPICSV4?

Clean design with few dependencies

- Depends only on pvData (more info later).
  - No dependencies on third-party software, not even middleware such as CORBA, DDS, ICE, etc.
  - Network and concurrency management can be reused from previous projects (e.g., *Channel Access for Java*).
- Clean separation of interface and implementation reduces coupling.
  - Extensive use of factory design pattern to allow changing of implementations without requiring modifications of code.



Asynchronous API and design

- When dealing with input/output or communication, asynchronous API allows for better application design.
  - Able to launch operations in parallel without having to spawn threads.
- Drawback: code is more complex even for simple operations.
  - A synchronous helper API will be provided.
- Example:
  - create a get request:

```
ChannelGet createChannelGet(
        ChannelGetRequester channelGetRequester, // Whom to notify
        PVStructure pvRequest,//  A structure describing the desired set of fields
        String structureName,// The name to give to the created PVStructure.
        boolean shareData,   // On the remote side should the companion
                             // PVStructure share data with the PVRecord.
        boolean process,     // Process before getting data.
        PVStructure pvOption // Additional options (e.g. triggering).
);
```

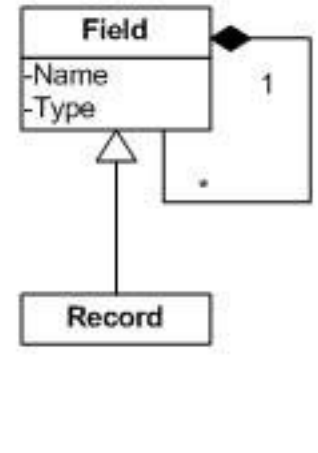
  - when the request is complete, callback on the requester is called:

```
void channelGetConnect(
        Status status,
        ChannelGet channelGet,
        PVStructure pvStructure,
        BitSet bitSet
);
```

Support for structured process variable (PV) data

- In EPICSv3, each record had fields, which were scalars or arrays.

- With **pvData**, a field can also be a structure.
  - Thus, record is a top-level field.



- Example:

```
powerSupply
    alarm
    timeStamp
    power
        value
        alarm
    voltage
        value
        alarm
    current
        value
        alarm
        output
            value
            ...
```

Connecting to several fields of a pvData structure

- In EPICSv3, each CA channel allowed connection to a single field.

```
Channel ch = context.createChannel("RECORD.VAL");
```

- In EPICSv4, a channel can connect to a subset of record's fields:

```
ChannelGet getReq = channel.createChannelGet(…,
  ChannelAccess.createRequest("alarm, timestamp"),
  …);
```

- Once a `ChannelGet` object is created, the same `get` request can be re-issued:

```
getReq.get(false);
getReq.get(false);
…
getReq.get(true); // last request
```

Client-specified filters

- Client can configure behavior of monitors to filter-out any changes that do not affect it.
  - The filtering is done already at the server-side (no network traffic).
  - The filters are client-specific: e.g., different clients might have different dead-band tolerances.

- These monitoring algorithms are available:
  - `onPercentChange`: if change is within `deadband` percent of the last reported value, it is not reported.
  - `onAbsoluteChange`: if change is within `deadband` of the last reported value, it is not reported.
  - `onChange`: report any change.
  - `onPut`: report whenever the value of the field is set.

- Additional monitoring algorithms can be registered at the server.
  - E.g., monitoring on an external trigger.
  - Client code must use the name with which the monitor is used at the server, and provide any needed parameters.

Flow control for monitors

- If changes are too frequent, server can generate monitors more frequently than they can be handled.
  - Bottleneck: network or client's CPU.

- Flow control allows the server to detect when the client can no longer accept monitor notifications:
  - TCP flow control.
  - Server monitors clients' receive buffers.

- Server has a queue for monitors. Queue size is configurable:
  - Shared: 0 – the server sends the data directly from the record
  - Cached: 1 – the server maintains the latest copy of the data
  - Queued: $n>1$ – n last versions of data are kept in a FIFO

Remote procedure calls

- In EPICSv3, remote procedure calls (RPC) were impossible to perform, unless in some special cases or with special approaches:
  - E.g., marshal invocation data in a waveform, and un-marshal in device support…
  - How to get the return value or completion status?
  - How to correlate return value with invocations (e.g., if several concurrent invocations are in progress).

- CA for EPICSv4 has a special provision for RPC-style communication: the `PutGet` request:
  - First put data to some subset of record's fields.
  - Wait until processing at the server completes.
  - Then get data from a subset of record's fields.

- Decreased beacon traffic
  - Server does not send beacons.
  - When server receives an echo request from the client, it responds.
  - Client only echoes a server if the server doesn't send data for a period of time.

- A note on compatibility
  - EPICSv4 CA protocol is not compatible with EPICSv3.
  - However, it is possible to use CA libraries simultaneously.
    - Access to JavaIOC database with EPICSv3 and EPICSv4 clients.
    - Also, JavaIOC can talk with EPICSv3 or EPICSv4 servers.

Plans

- Distributed queries
  - Queries such as: "*find all beam position monitors*"
- IP multicast monitors
  - When several clients subscribe for same data, it would be possible to send the data to all of them.
    - A single send operation for the server.
    - The dispatching performed by network infrastructure (switches).
  - Technique: IP multicasting.
  - Requires UDP protocol.
    - Difficult to ensure reliable delivery and flow control.
- Access control
  - Presently, no access control checks are done.
  - At what level of granularity should access control be applied?
  - Ideally compatible with EPICSv3.
- TCP transport improvements
  - A stream-like API to upper levels…
  - …taking into account MTU size when transmitting data

C++ implementation

- The development focuses on Java
  - Quick and efficient prototyping and development
- Other implementations are planed
  - In particular, C++
- Implementation will commence when Java design and implementation are stable

Conclusion

- Development of EPICSv4's Channel Access has reached a point where it can be used for first applications.
  - Concept-wise backward compatible with EPICSv3.
  - EPICSv4 applications can talk to EPICSv3, and vice-versa.
  - New features (such as RPC) reduce the "feature gap" with CORBA/ICE/RMI/SOAP and similar middleware.
  - Foreseen improvements (TCP transport improvements, multicasting) likely to reduce "performance gap" with state-of-the-art middleware (e.g., commercial DDS implementations).
  - Remains concentrated to control systems (monitor quality of service, etc.).
- JavaIOC
  - Infrastructure is in place.
  - No device support drivers yet, but suitable for high-level applications, integration with other systems, etc.
- Your input?
  - Now is a great time for considering new features and adjusting priorities.
- Have an application?
- Available on Sourceforge
  - http://epics-pvdata.sourceforge.net/

Thank You for Your Attention