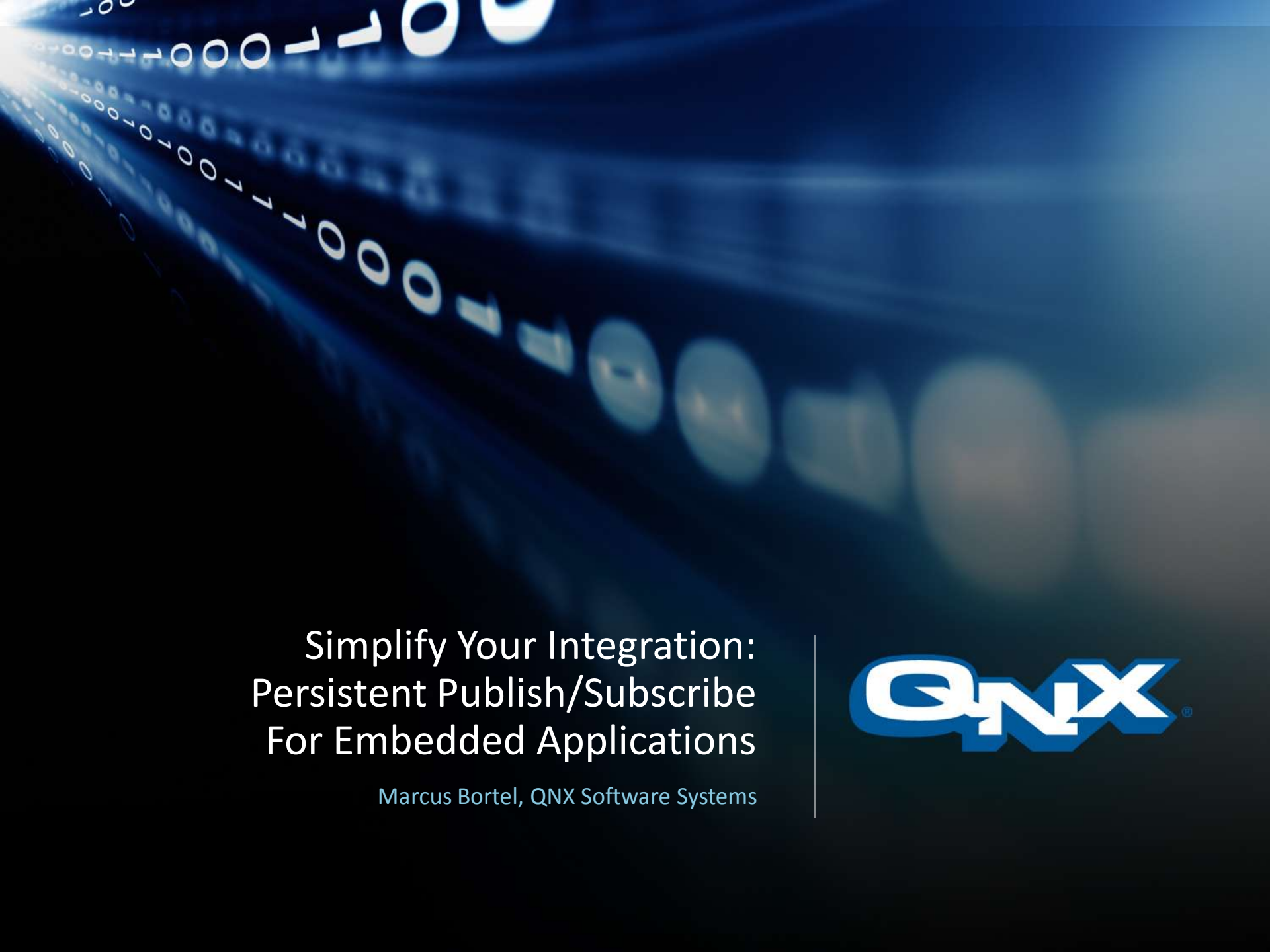


Simplify Your Integration: Persistent Publish/Subscribe For Embedded Applications

Marcus Bortel, QNX Software Systems

QNX

Introduction:
Challenges of Complex Systems

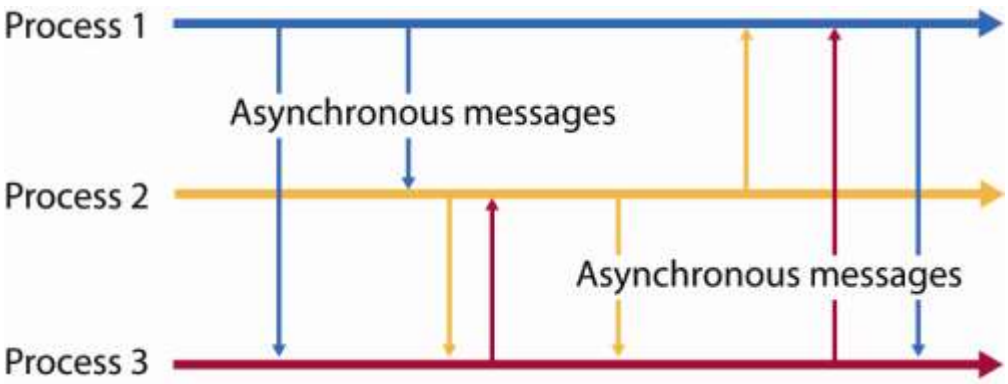
- Reliability & Availability
  - OS
- Design flexibility
- Scalability
- Connectivity
  - Network
  - Multiple devices and technologies
- HMI design
  - Integrate multiple technologies: OpenGL ES, Qt, etc.
- Resource separation (e.g. sandbox)
- Branding and re-purposing core product
- Development time
- Certification
  - IEC 62304, IEC 61508, ISO 13485, ISO 1497, etc.

We'll Learn About …

- Messaging models
  - Asynchronous
  - Synchronous
  - Persistent Publish/Subscribe
- What is PPS?
- How PPS works
- How PPS can help with the challenges of designing and building complex systems

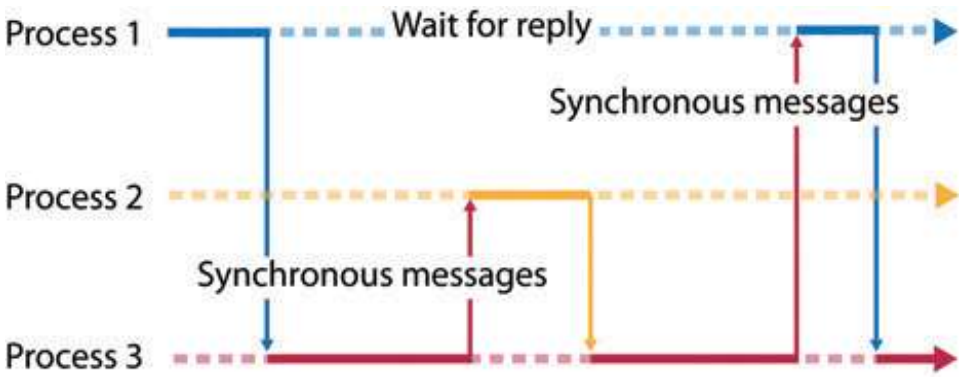
Asynchronous Messaging

- Well known and widely implemented
- Not ideal for systems with many devices and components
- Low-level solution that:
  - Pushes error handling, end-to-end semantics and buffer management up to the application level
  - Need protocols to ensure:
    - Correct behavior of messaging across all applications
    - Sufficient memory for applications



Synchronous: Send/Receive/Reply

- Very valuable in real-time environments
  - Many processes require responses to their messages before they proceed
  - System framework handles messaging errors and message buffers
- Not ideal for systems with many devices and components
  - Every server communicates directly with its clients and must know how to respond to all client messages
  - Change to one software component may require changes to others
  - Does not scale easily



Publish/Subscribe

- Publish/Subscribe
- 20+ years: K. P. Birman and T. A. Joseph (1987)
  - Virtual synchrony: “a fault-tolerant asynchronous bulletin board mechanism”
- Many examples of Publish/Subscribe implementations
  - Nortel Networks: network monitoring and reporting systems (DMS-100, etc.)
- ACM (Association for Computing Machinery) www.acm.org
- Hundreds of papers

- a.k.a **The Observer Pattern**

Persistent Publish/Subscribe: PPS

- Publish/Subscribe with *persistence* across reboots
- Embedded applications that support
  - Many devices and software components
  - Sophisticated HMI that combines multiple technologies: Qt, OpenGL ES, C

PPS Case Study: Smart Energy Manager

- Design flexibility
- HMI design
  - HTML5
  - Crank Storyboard
  - Elektrobit Guide

- Connectivity
  - Zigbee wireless network
  - Insteon power-line based Home Area Network (HAN) for lighting control
  - IP video cameras
  - Internet

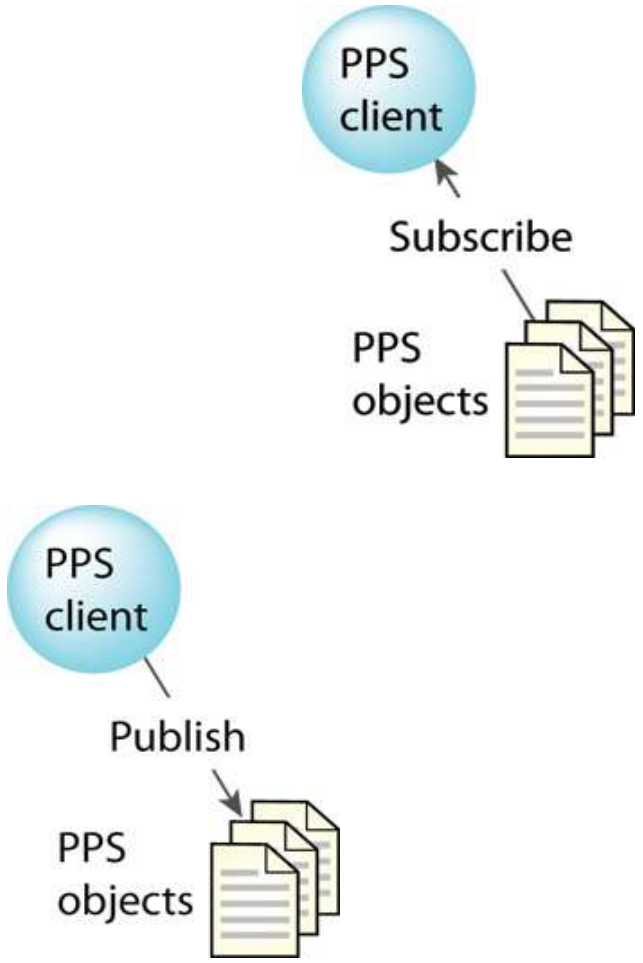
PPS Case Study: Medical Data Aggregator

- Design flexibility
- Scalability
- Connectivity
  - Database
  - BlackBerry PlayBook
- HMI design
  - Qt
  - C
  - Adobe AIR

- Some components
  - Blood pressure
  - Spirometry
  - Pulse oximeter
  - ECG

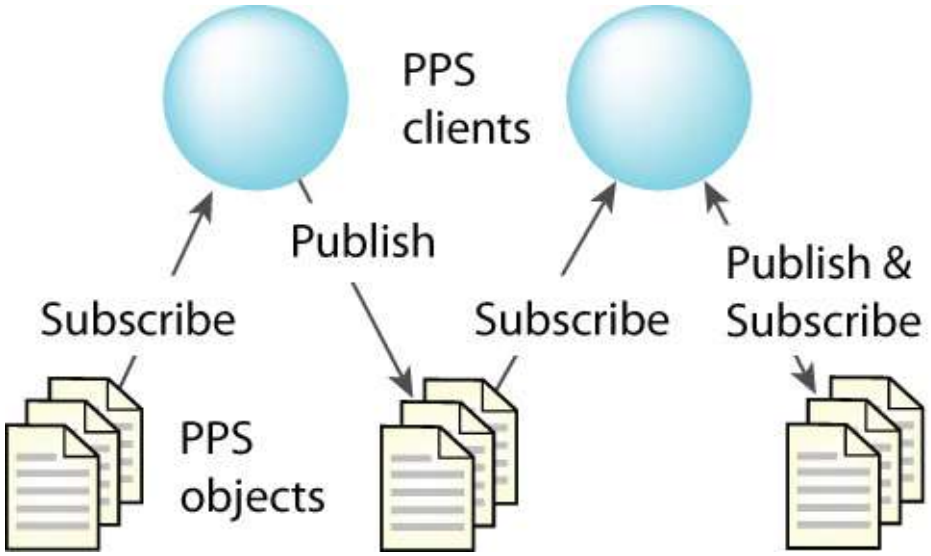
Messaging Architecture

- Loosely coupled publisher-subscriber architecture
- Publishing is asynchronous
- PPS client
  - Publish only
  - Subscribe only
  - Publish and subscribe
  - Subscribe to multiple objects



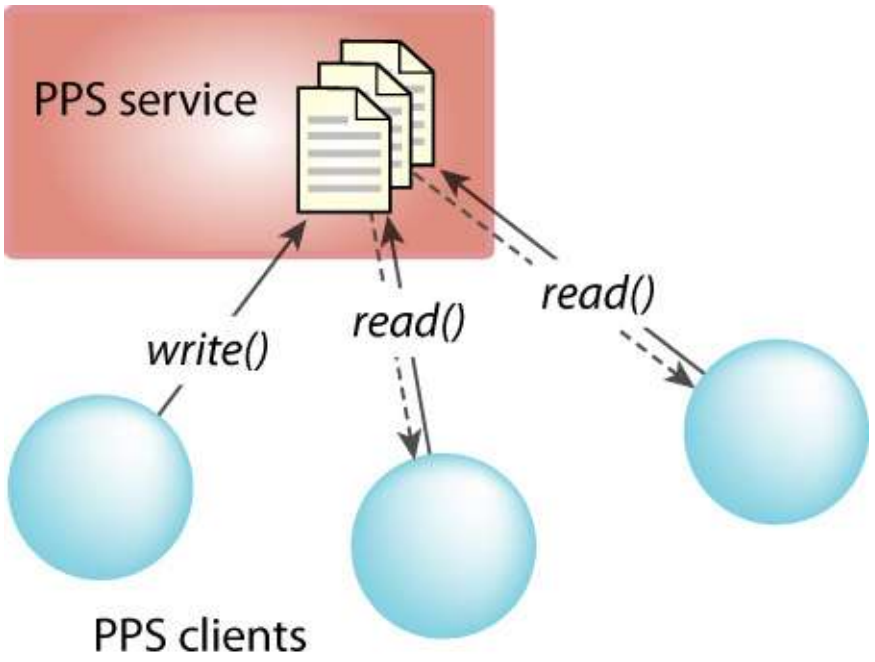
PPS Clients

- Must know which PPS objects are of interest
  - Publishers must know what to publish and when
  - Subscribers must know to which objects they must subscribe, and which object attributes are of interest
- Error and buffer management only for
  - *open()*, *read()* and *write()* POSIX API calls
  - Confirming that they can make sense of what they read
  - Setting reads to be blocking or non-blocking
- Need to know only that
  - Message has been read
  - Able to parse what was read
- Subscribers use *read()* calls to retrieve objects
  - Ergo: don't need to manage buffers for these objects



PPS Objects

- Integrated into the PPS file system pathname space
  - Publishers modify objects and their attributes, and write them to the file system
  - When a publisher changes an object, the PPS service informs all clients subscribed to that object of the change
- Publishers can use the same object to communicate to all subscribers to that object
- Can have multiple publishers and subscribers



Binary or Human-readable Objects?

- PPS can use either binary or human-readable objects
- Human-readable objects and attributes
  - Benefits to development and debugging may outweigh the cost of the larger objects
- Debug from the command-line
  - File system utilities
  - **`cat`** for subscribe

```
cat /pps/media/PlayCurrent
cat /pps/media/.all?wait
```

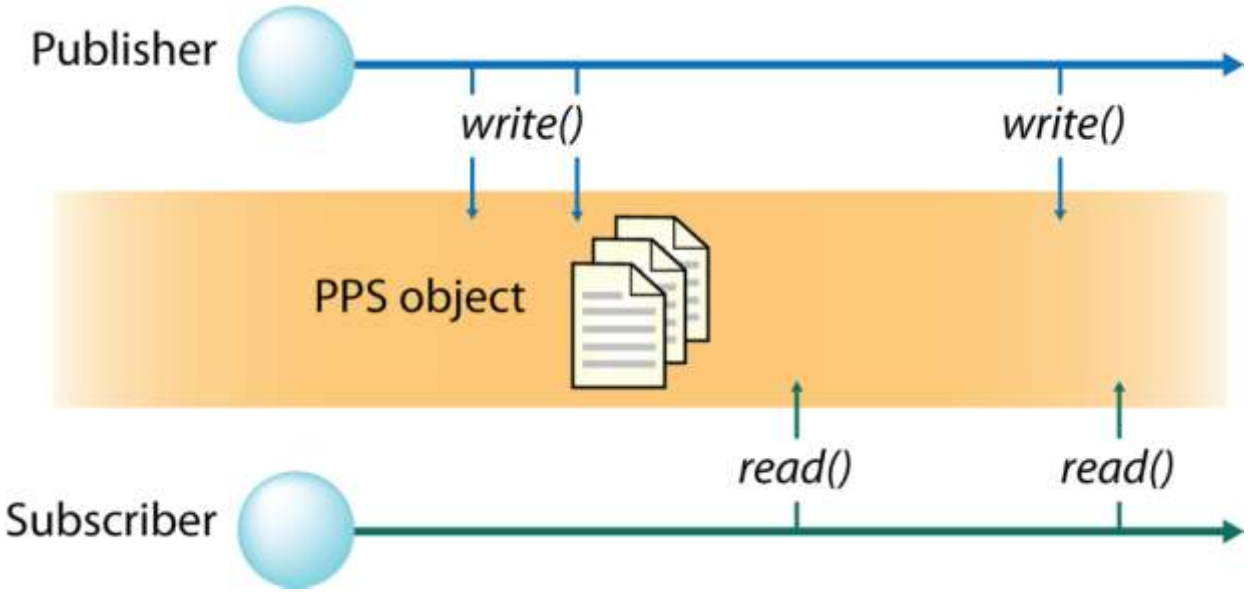
  - **`echo`** for publish

```
echo "attr::value" >>/pps/objectfilename
```

- Simple script
  - Subscribes to an object
  - Prints out debugging information, including PPS object and attributes

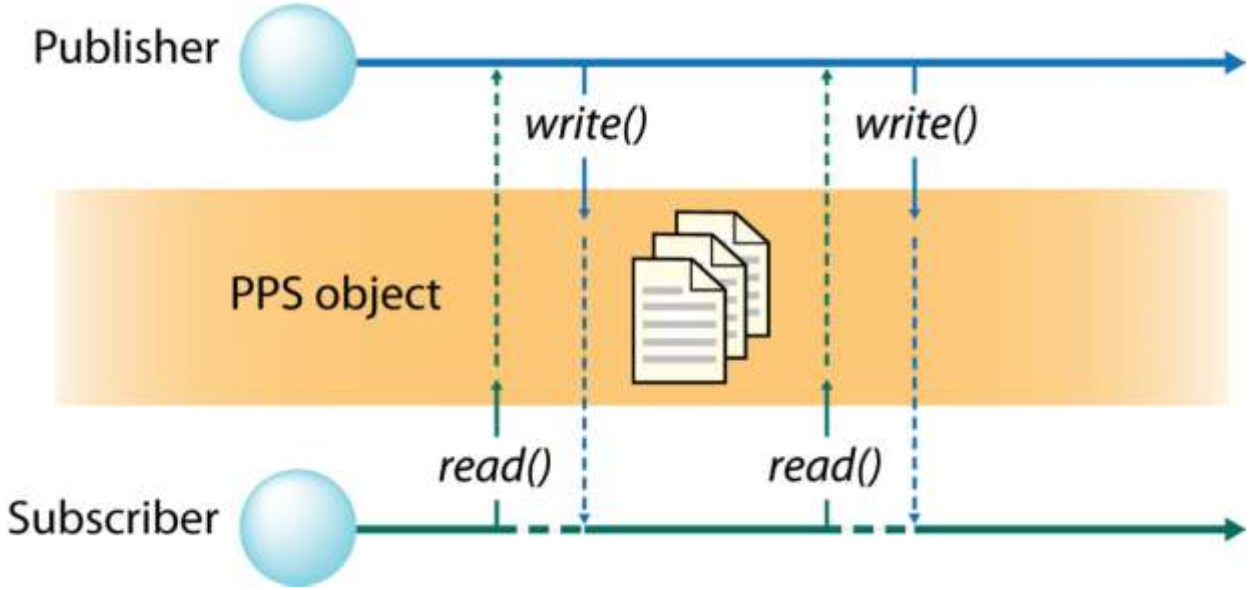
Push or Pull Publishing?

- *Push* publishing system
  - Publishers push data to objects
  - Subscribers read data upon notification, or at their leisure

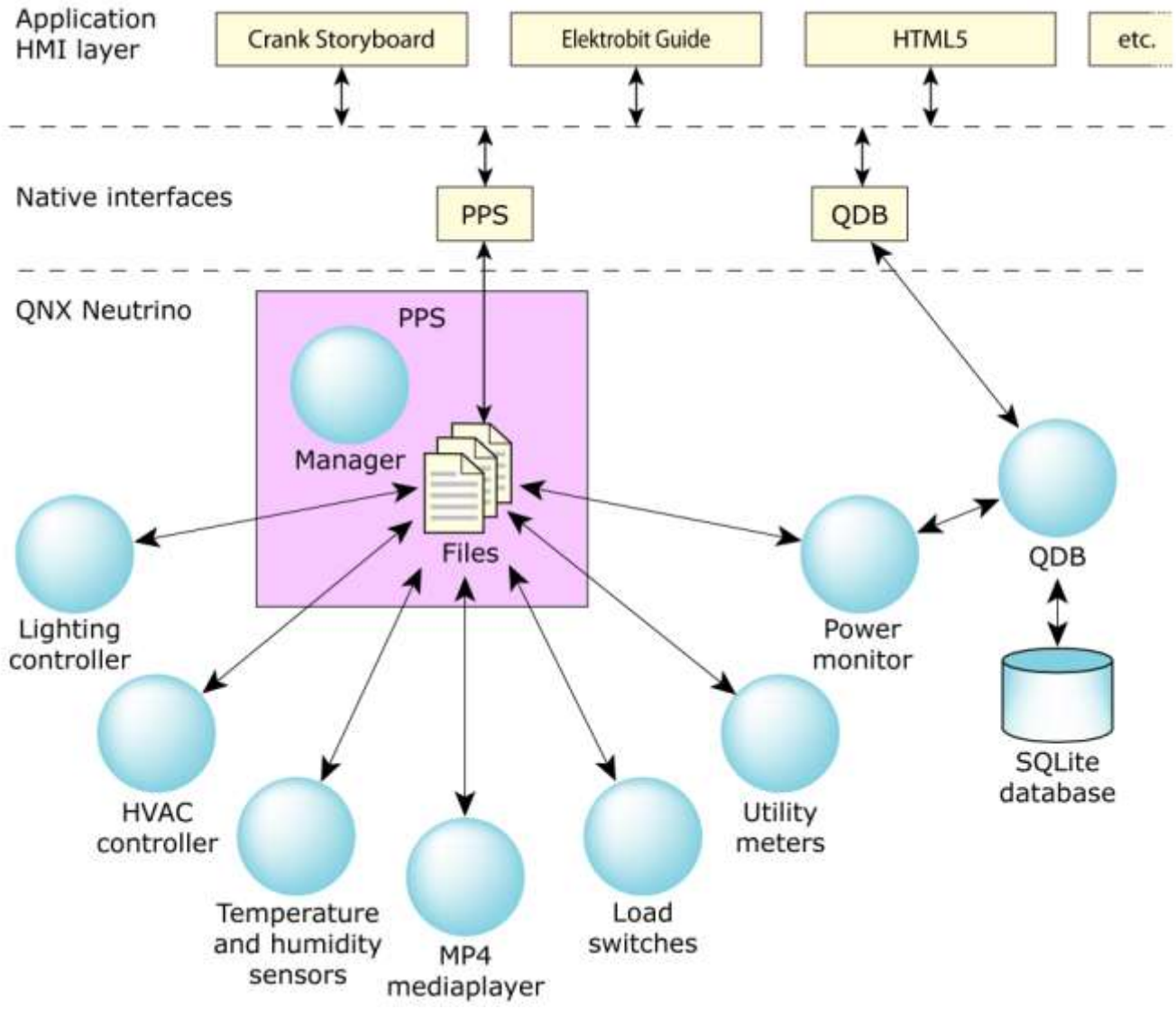


Push or Pull Publishing?

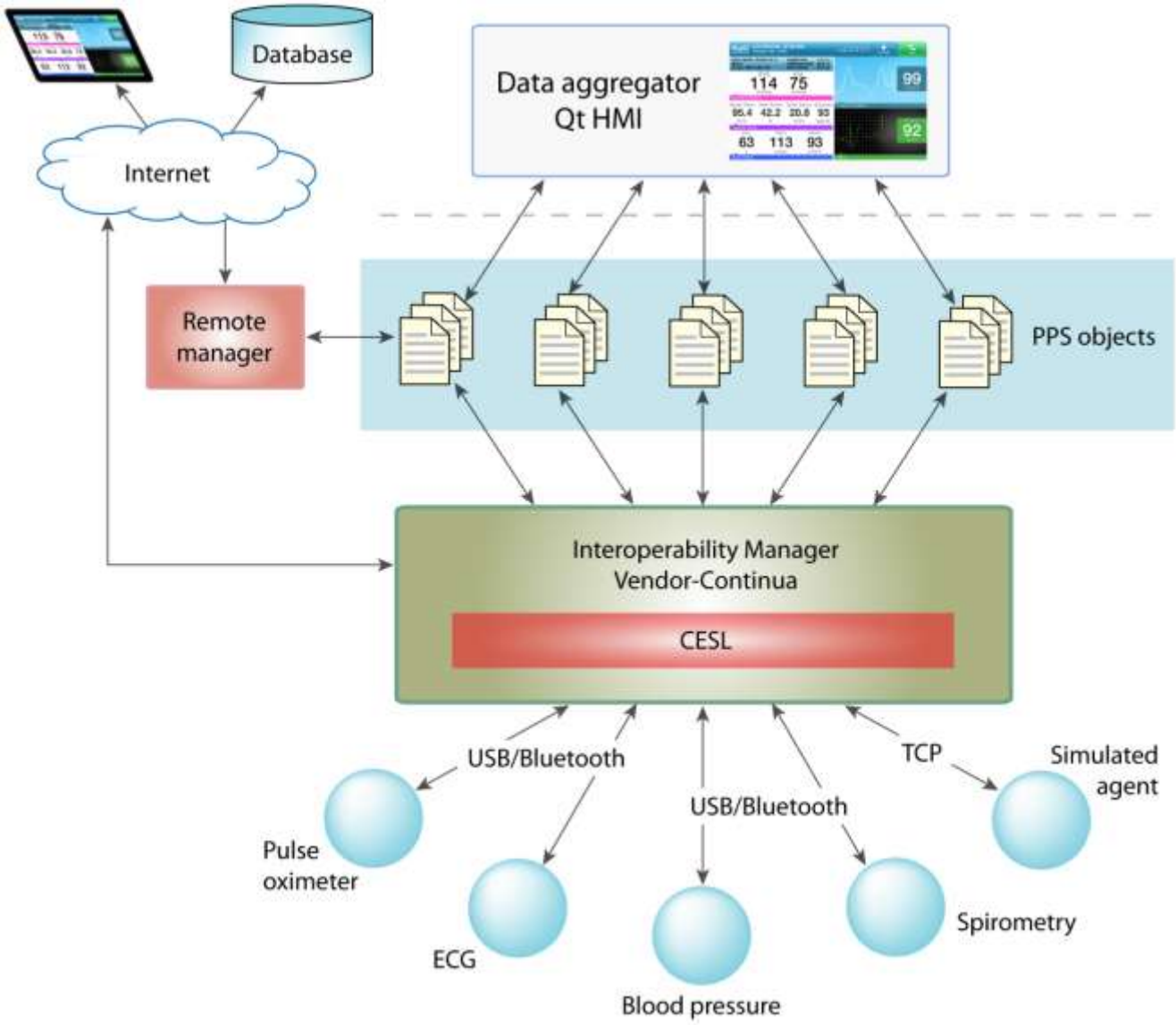
- *Pull* publishing system
  - Some data changes too quickly for push publishing
    - e.g. packet counts on an interface
  - Subscriber opens object with `pull` option
  - Issues *read()* call
  - Publishers to the object notified to write current data
  - Subscriber's read blocks, then returns with the new data
  - On-demand publishing



Under the Hood: Smart Energy Management

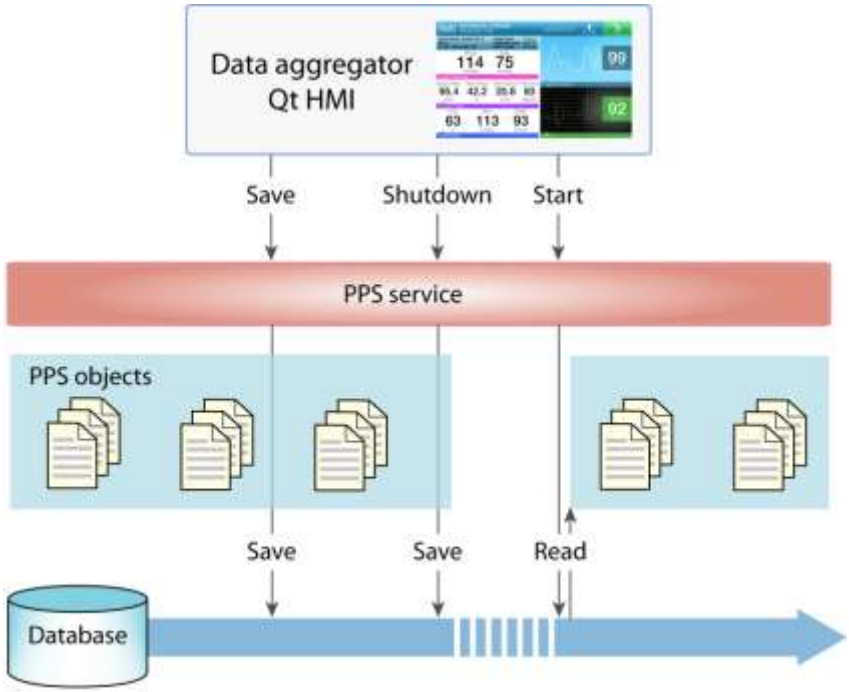


Under the Hood: Medical Data Aggregator



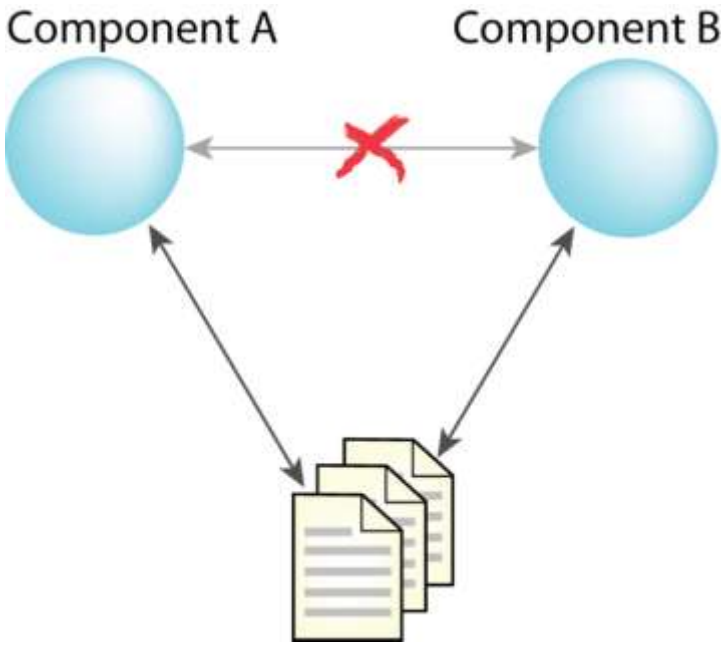
Persistence

- Needs reliable file system
  - Hard disk, NAND or NOR Flash, custom file system
- Maintains data across reboots
- Saves objects to persistent storage
  - On demand
  - At shutdown
- Restores objects on startup
  - Immediately
  - First access (deferred loading)
- Simplifies startups



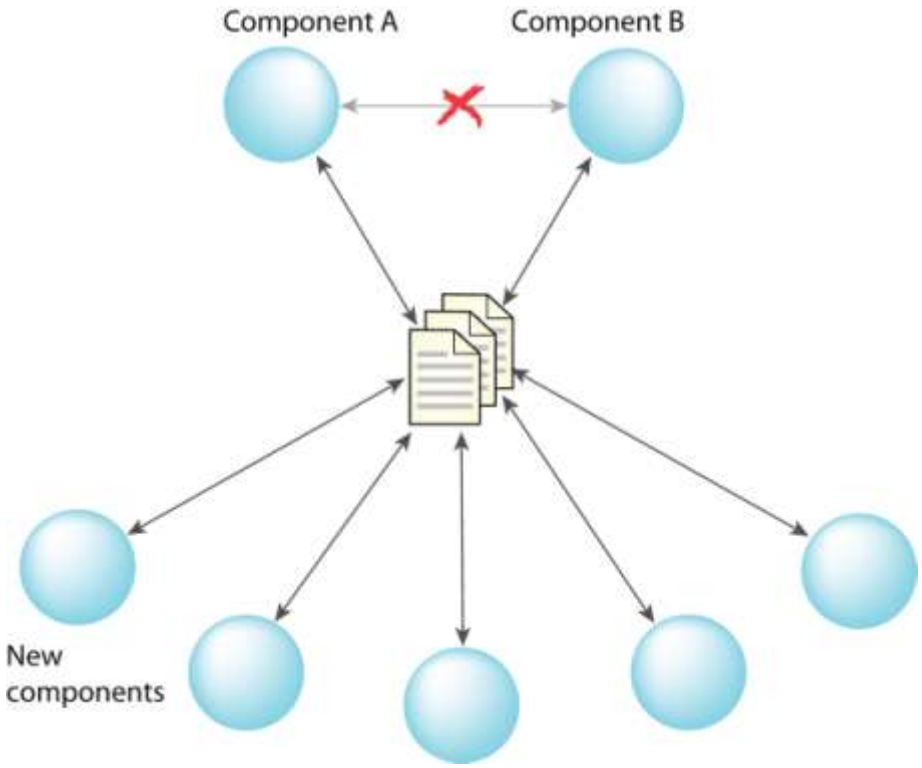
Design Flexibility

- Publisher and subscriber do not know each other
  - Only connection is through an object
- Flexibility when designing a system
- Data flow and module connection points
  - Not hardcoded
  - Not directly linked
- Delay decisions on module connection points and data flow until runtime



System Scalability

- Add components without increasing system complexity
- Only need to determine
  - What the new components publish
  - What data they need other PPS clients to publish
- No fine-tuning of APIs is required



Conclusion

- PPS messaging architecture
  - Flexible design
  - Scalability
  - Easily add devices and software components
  - Connectivity
  - Change, adapt, expand without touching the original
  - Design stability

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