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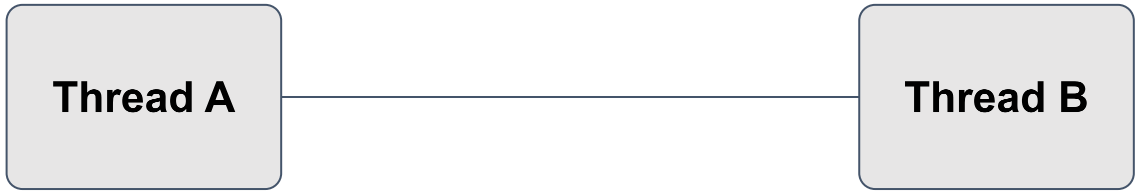
ZBus - the lightweight and flexible Zephyr message bus

Rodrigo Peixoto, *Edge-UFAL/Citrinio*
@rodrigopex

Motivation

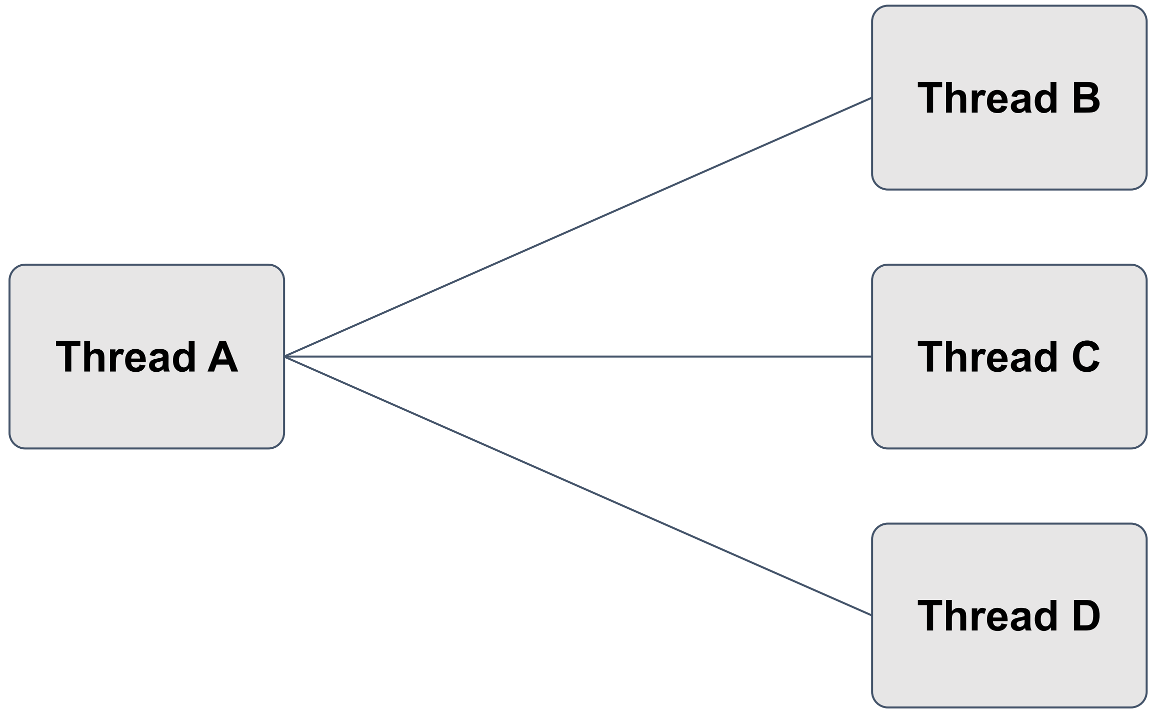
ONE-TO-ONE



FIFO	✅
LIFO	✅
Stack	✅
Message queue	✅
Mailbox	✅
Pipe	✅

Motivation

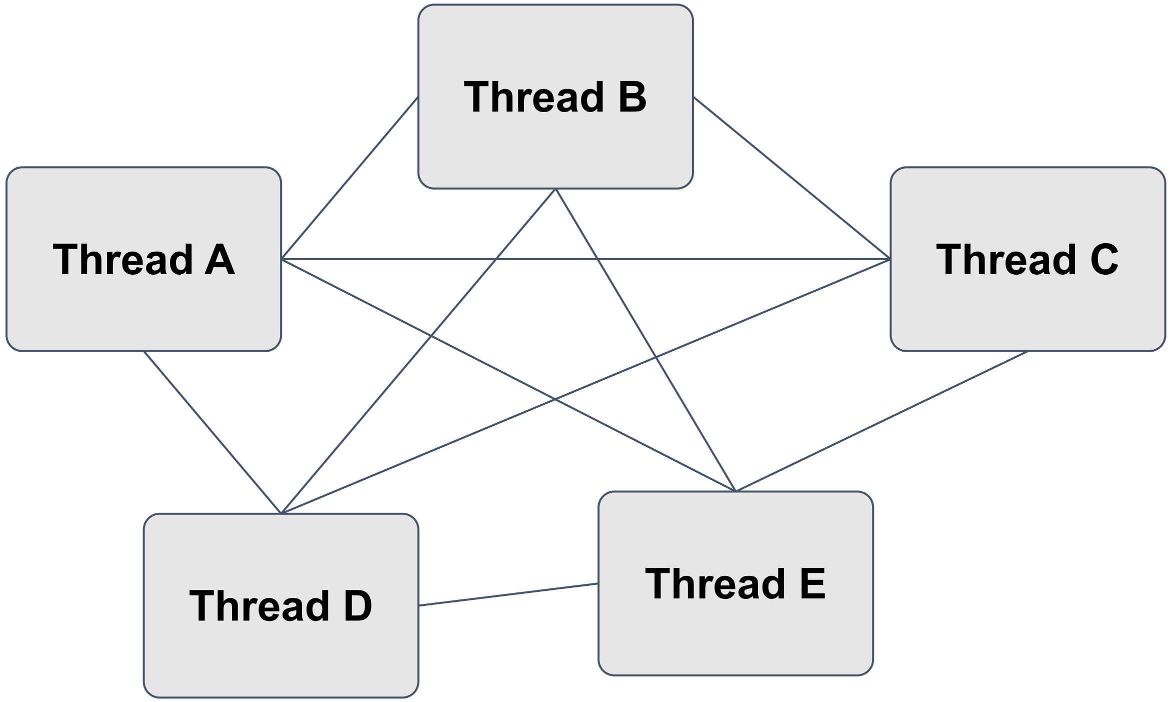
ONE-TO-MANY



FIFO	❌
LIFO	❌
Stack	❌
Message queue	❌
Mailbox	—
Pipe	❌

Motivation

MANY-TO-MANY



FIFO	❌
LIFO	❌
Stack	❌
Message queue	❌
Mailbox	➖
Pipe	❌

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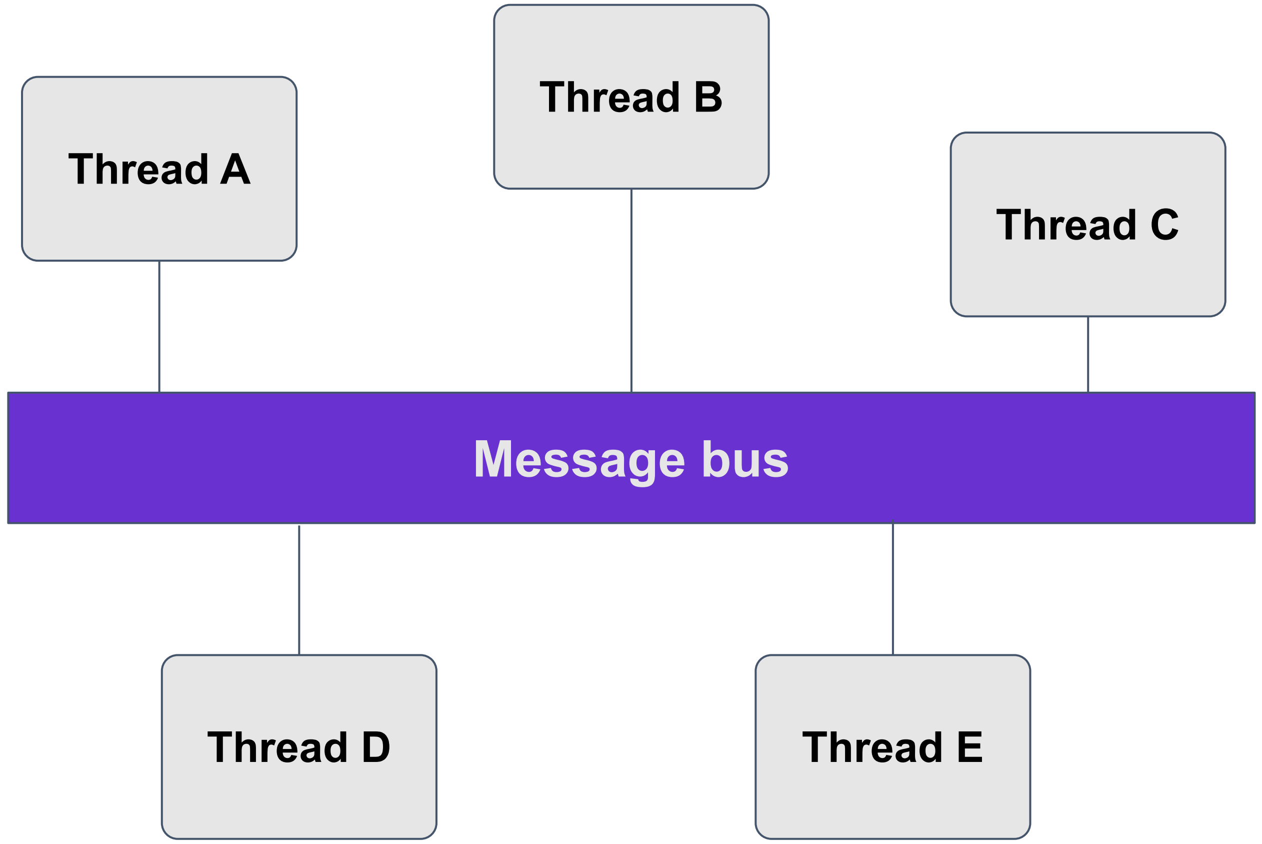
Solution idea

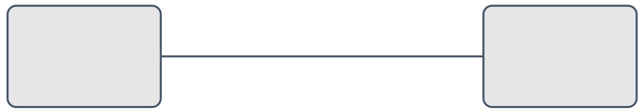


FIFO	❌
LIFO	❌
Stack	❌
Message queue	❌
Mailbox	❌
Pipe	❌
Bus	✅

Bus topologies

✅

ONE-TO-ONE



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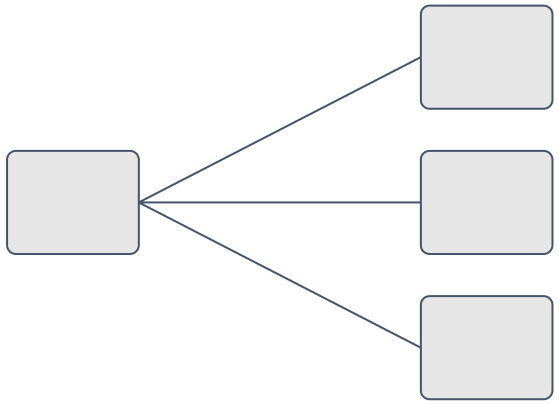
ONE-TO-MANY



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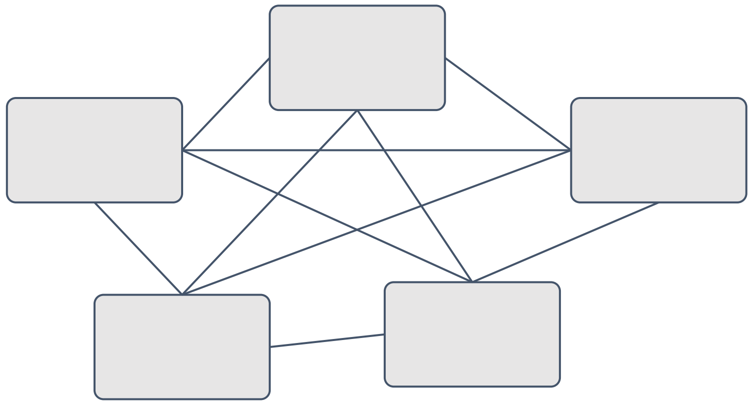
MANY-TO-MANY



Embedded systems challenges

- Memory constraints
- Processing limitations
- Battery-powered devices

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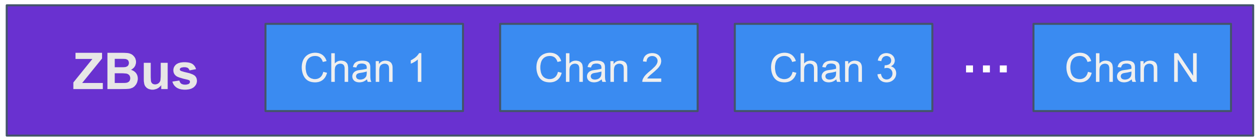
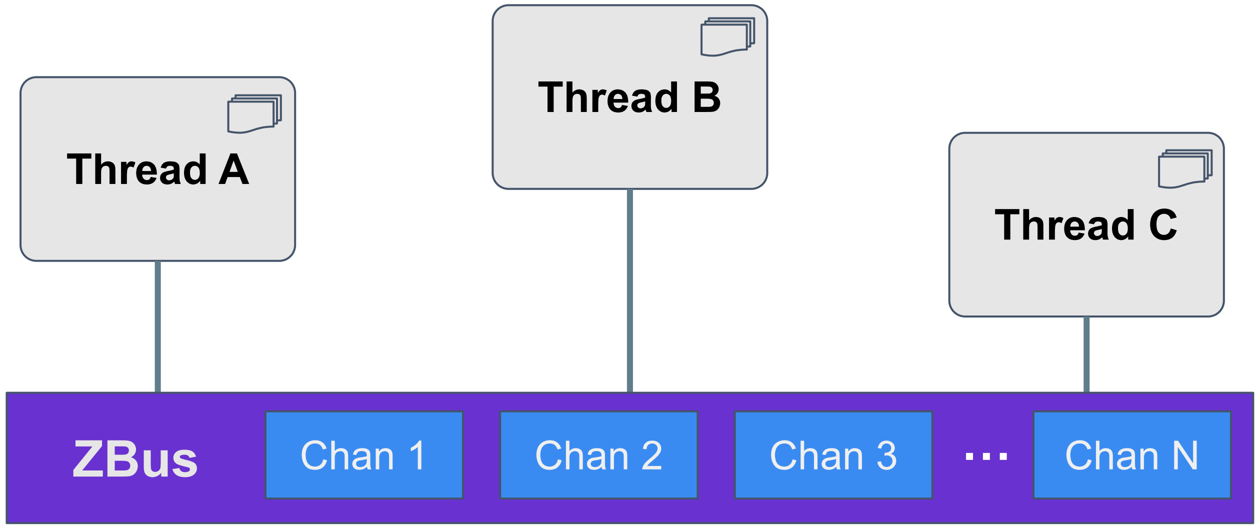

ZBus
Chan 1
Chan 2
Chan 3
...
Chan N

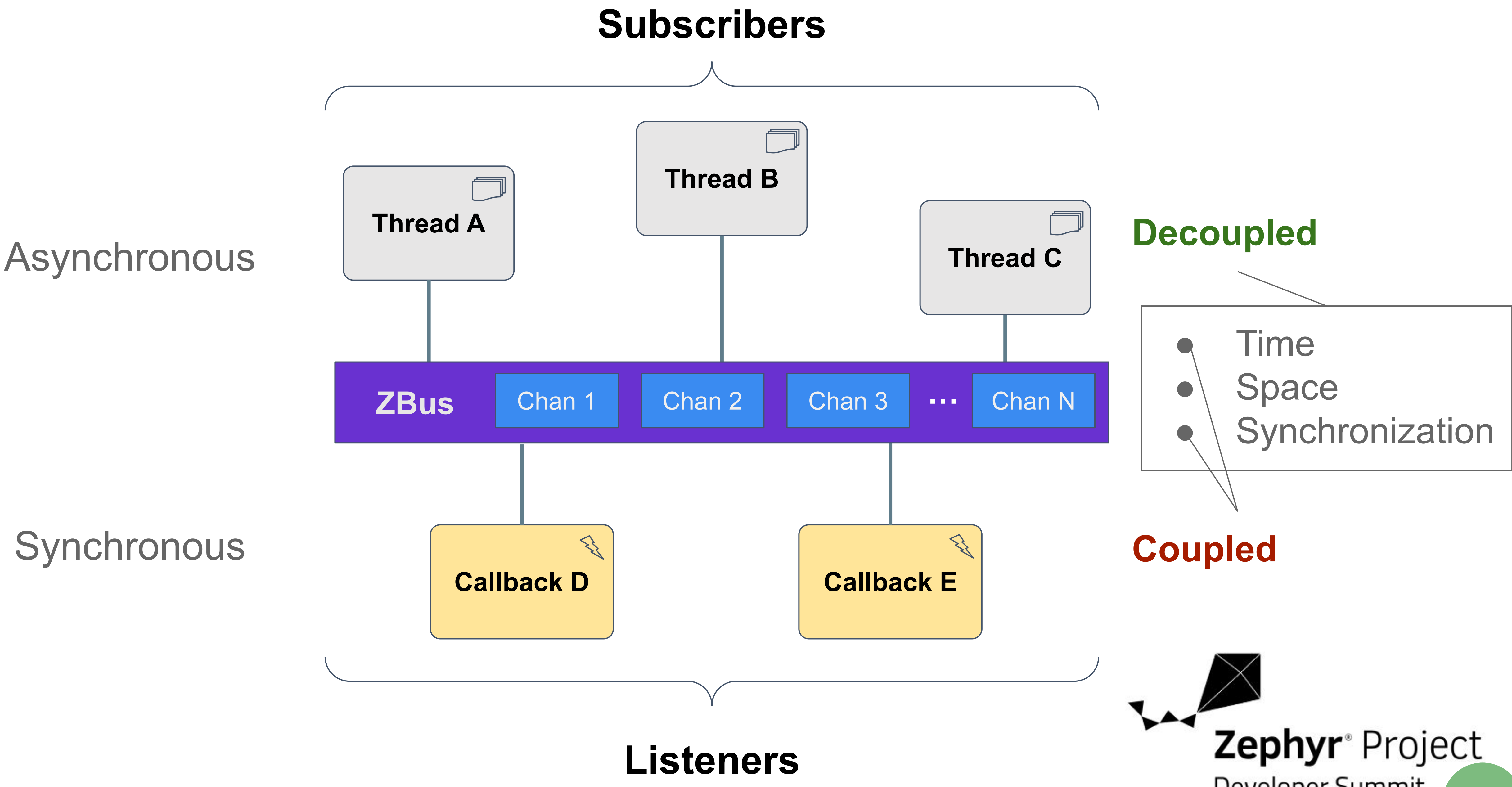
Subscribers

Asynchronous

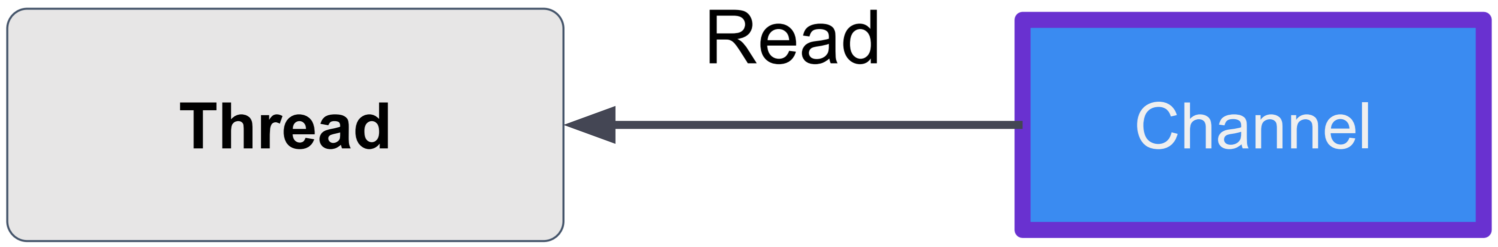


Decoupled

- Time
- Space
- Synchronization


Subscribers
Asynchronous
Thread A
Thread B
Thread C
ZBus
Chan 1
Chan 2
Chan 3
...
Chan N
Synchronous
Callback D
Callback E
Listeners
Decoupled
Time
Space
Synchronization
Coupled

Available actions



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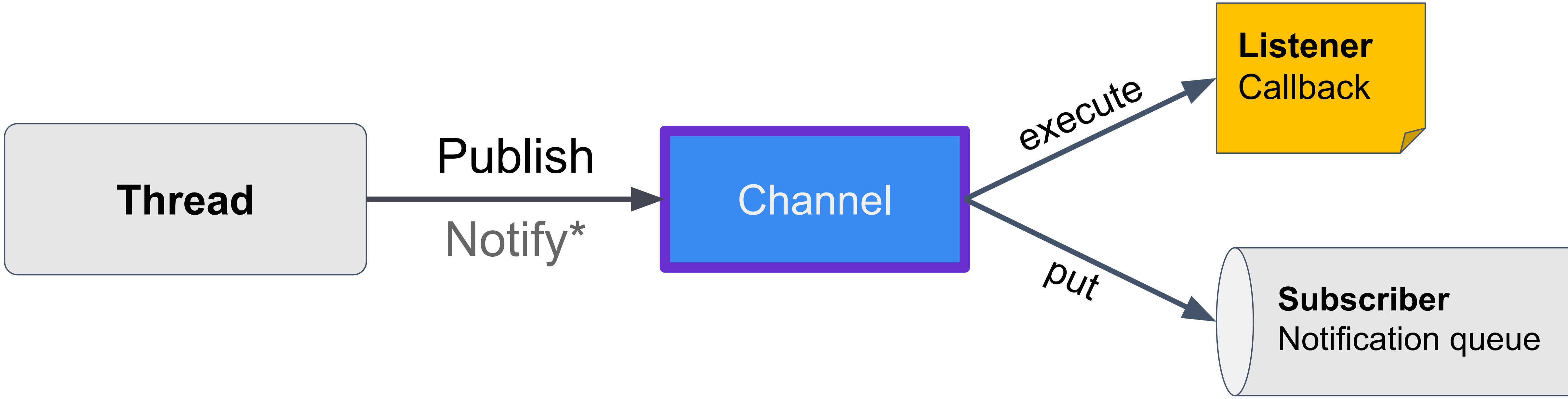
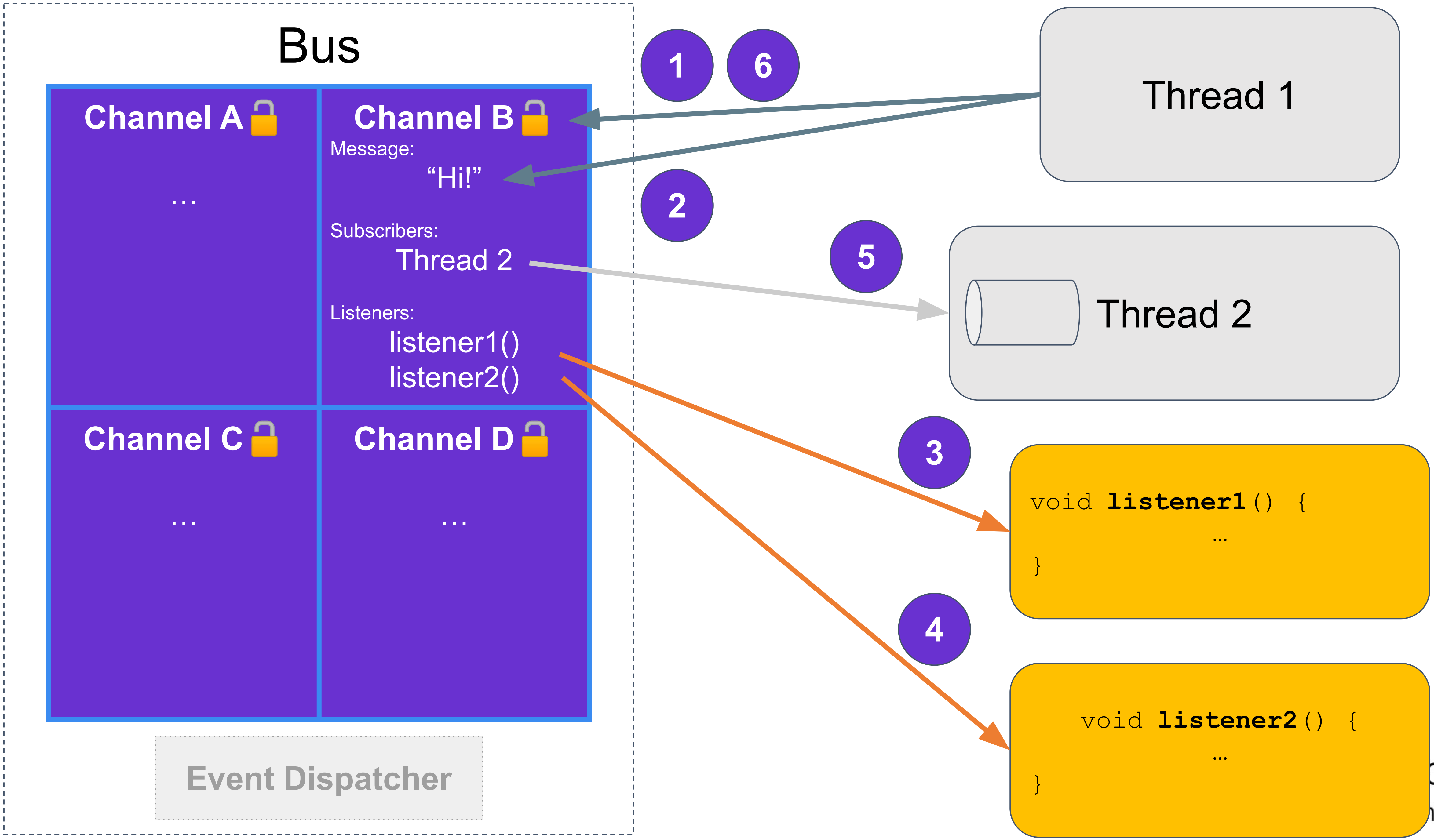
Available actions





```
void listener1() {
        …
}
```

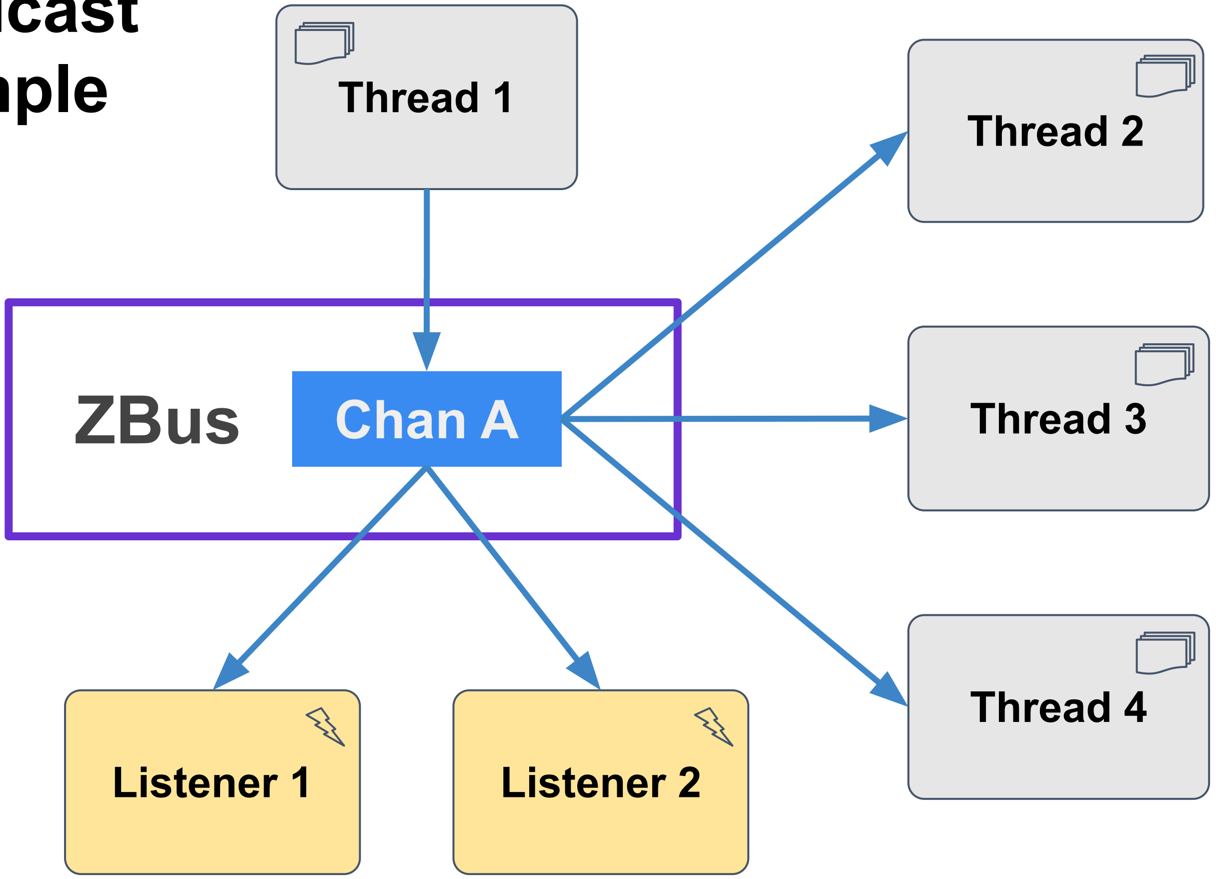
```
void listener2() {
        …
}
```

Virtual Distributed Event Dispatcher

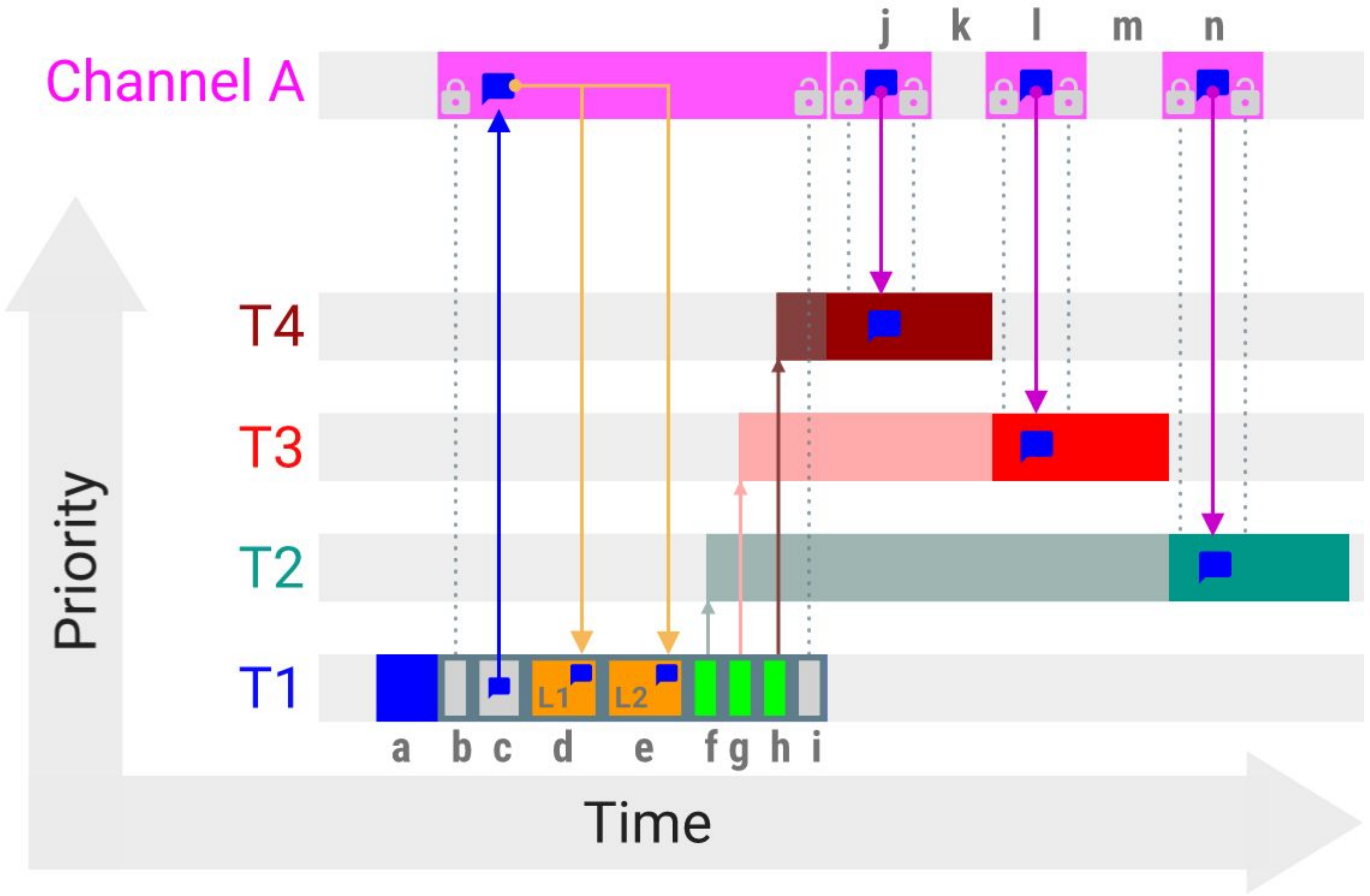
VDED is the bus logic responsible for sending notifications about message publications to the channel's observers. There is no central entity that acts as an event dispatcher on ZBus.

Virtual Distributed Event Dispatcher

Broadcast example



Virtual Distributed Event Dispatcher



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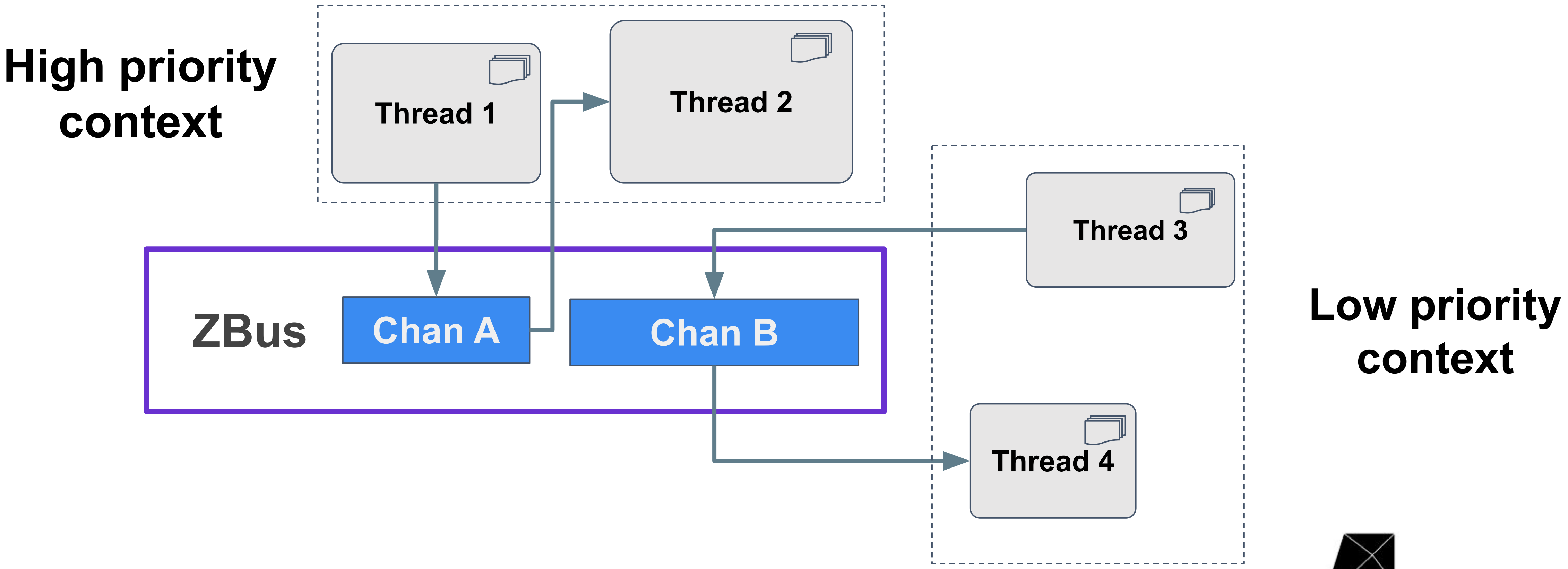
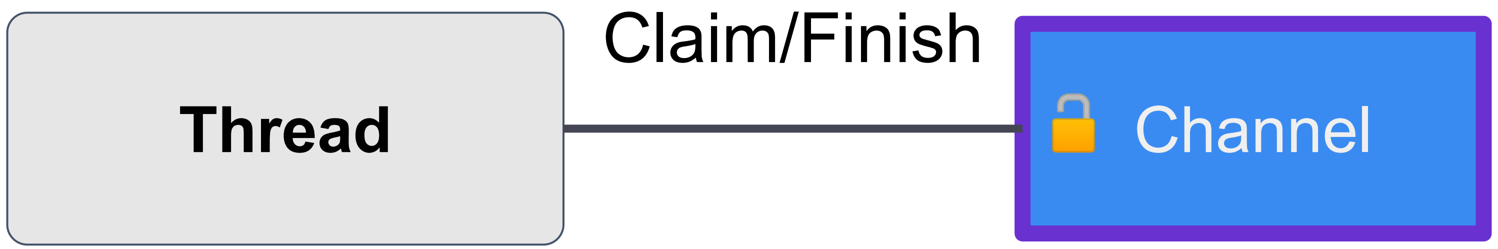
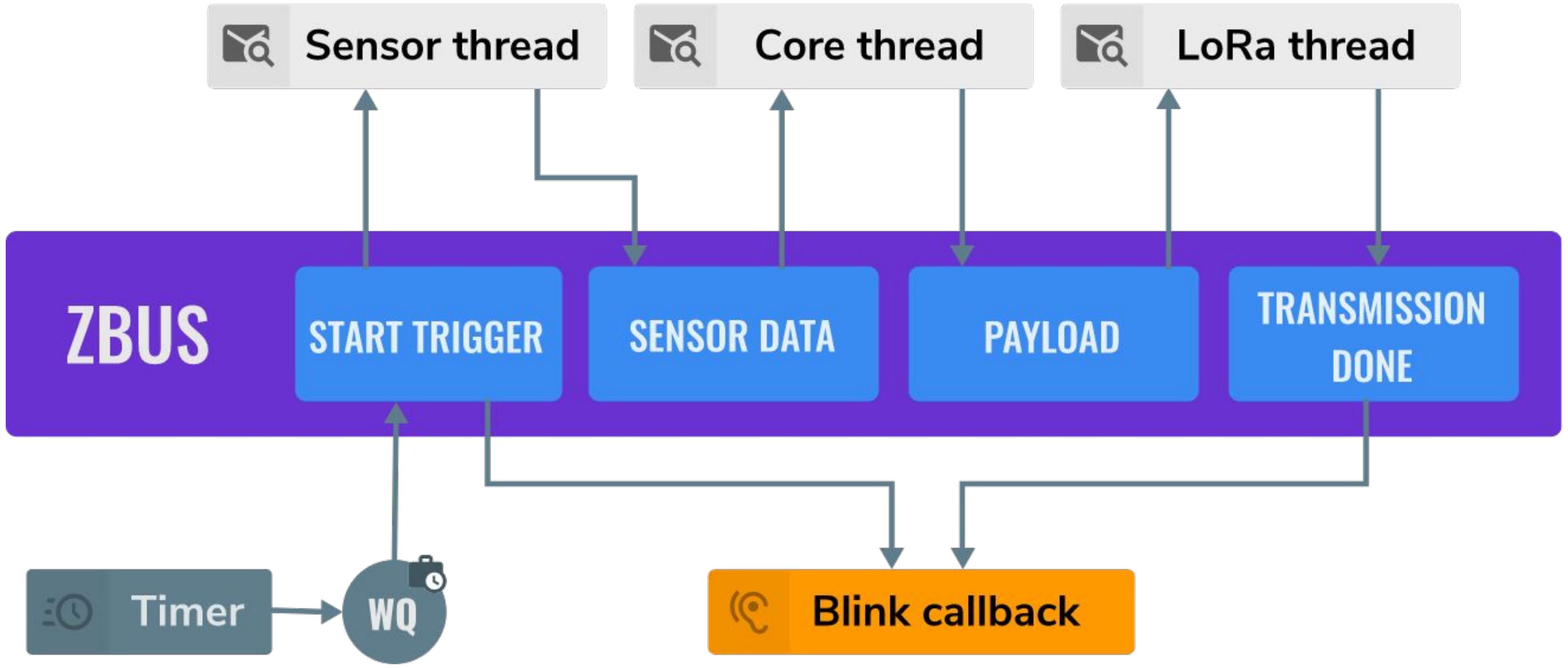
Virtual Distributed Event Dispatcher



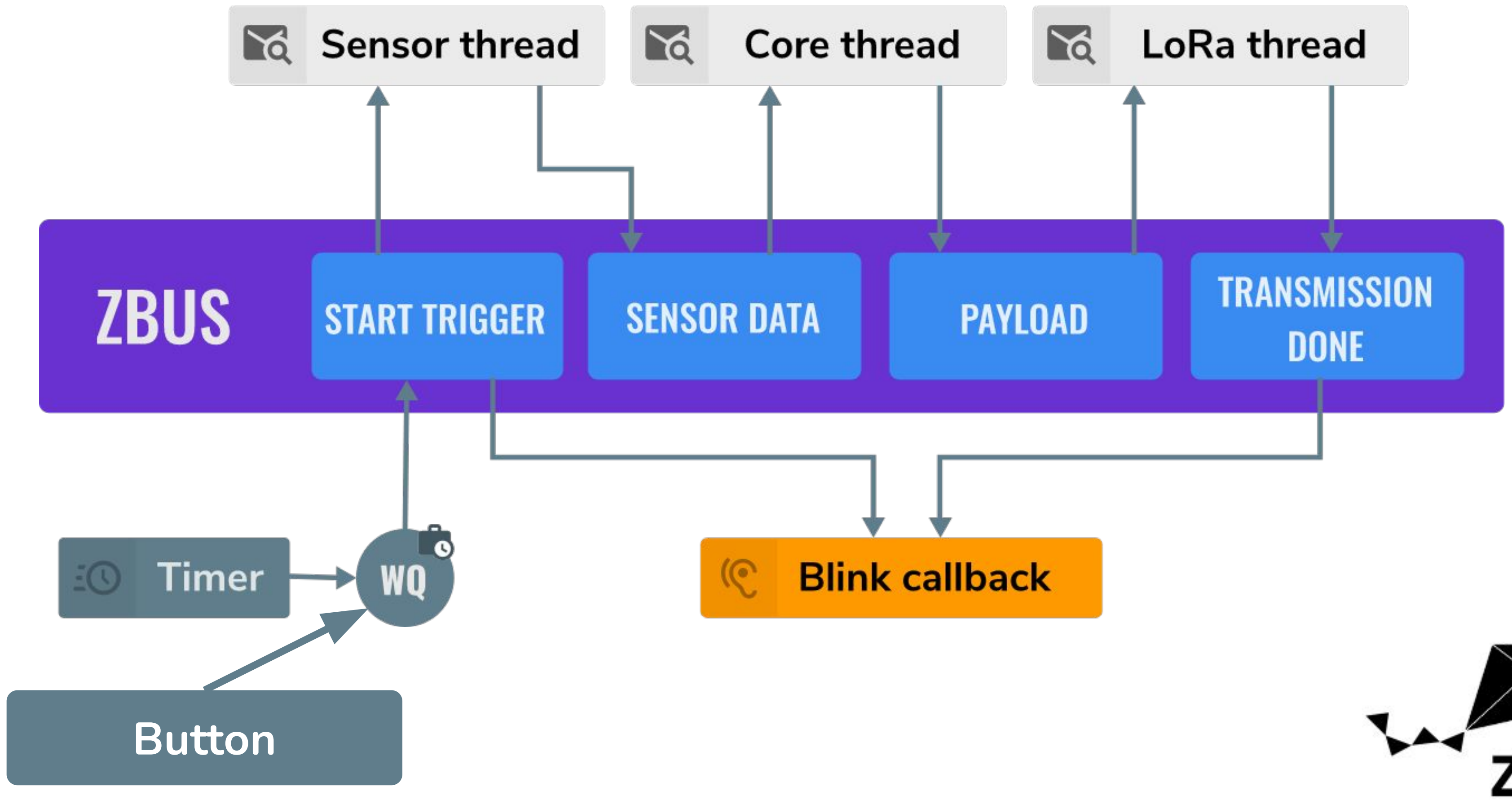
Available actions



Example


Sensor thread
Core thread
LoRa thread
ZBUS
START TRIGGER
SENSOR DATA
PAYLOAD
TRANSMISSION DONE
Timer
WQ
Blink callback

Example


Sensor thread
Core thread
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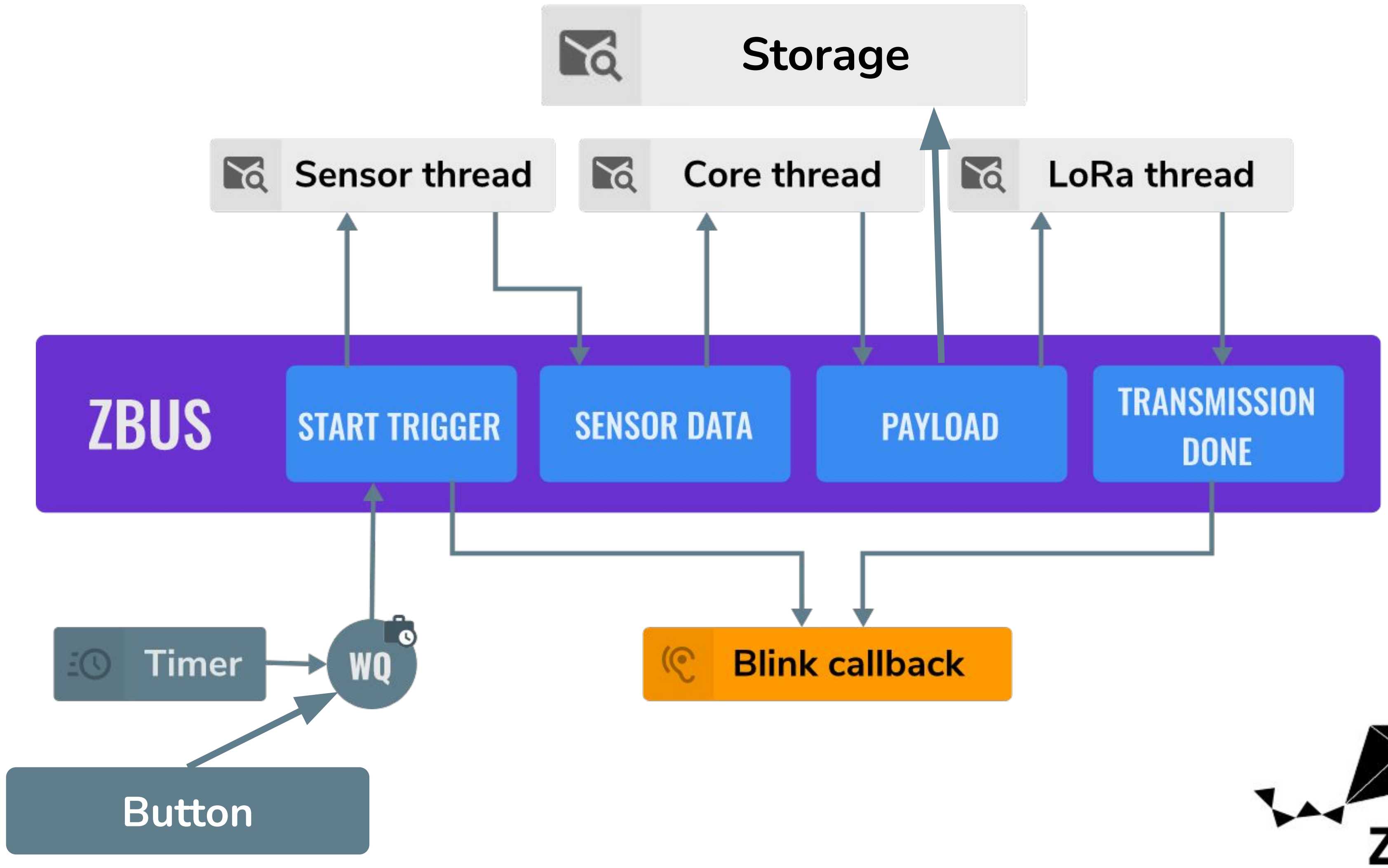
Button

Example


Storage
Sensor thread
Core thread
LoRa thread
ZBUS
START TRIGGER
SENSOR DATA
PAYLOAD
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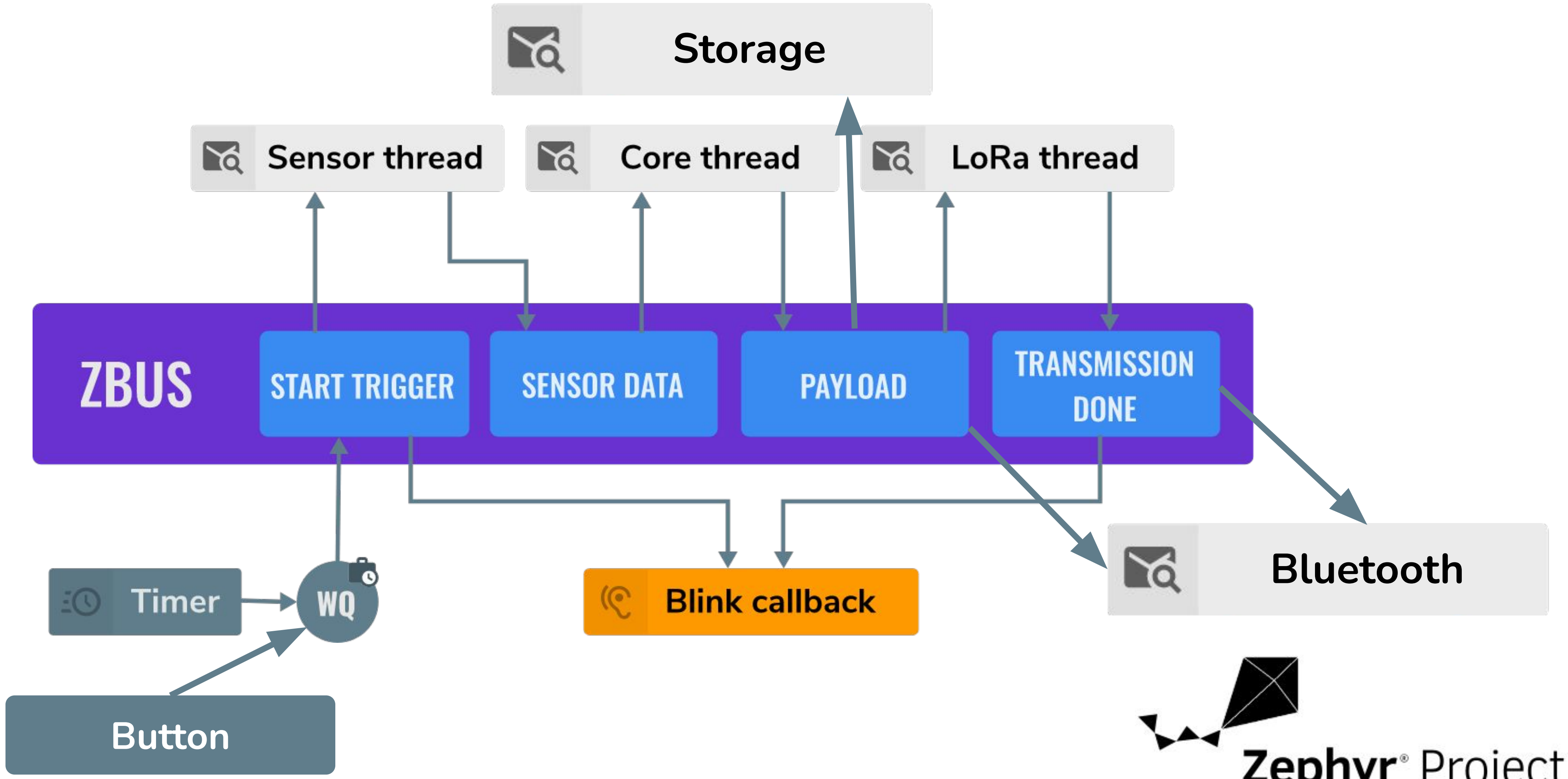
Blink callback
Button

Example


Storage
Sensor thread
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PAYLOAD
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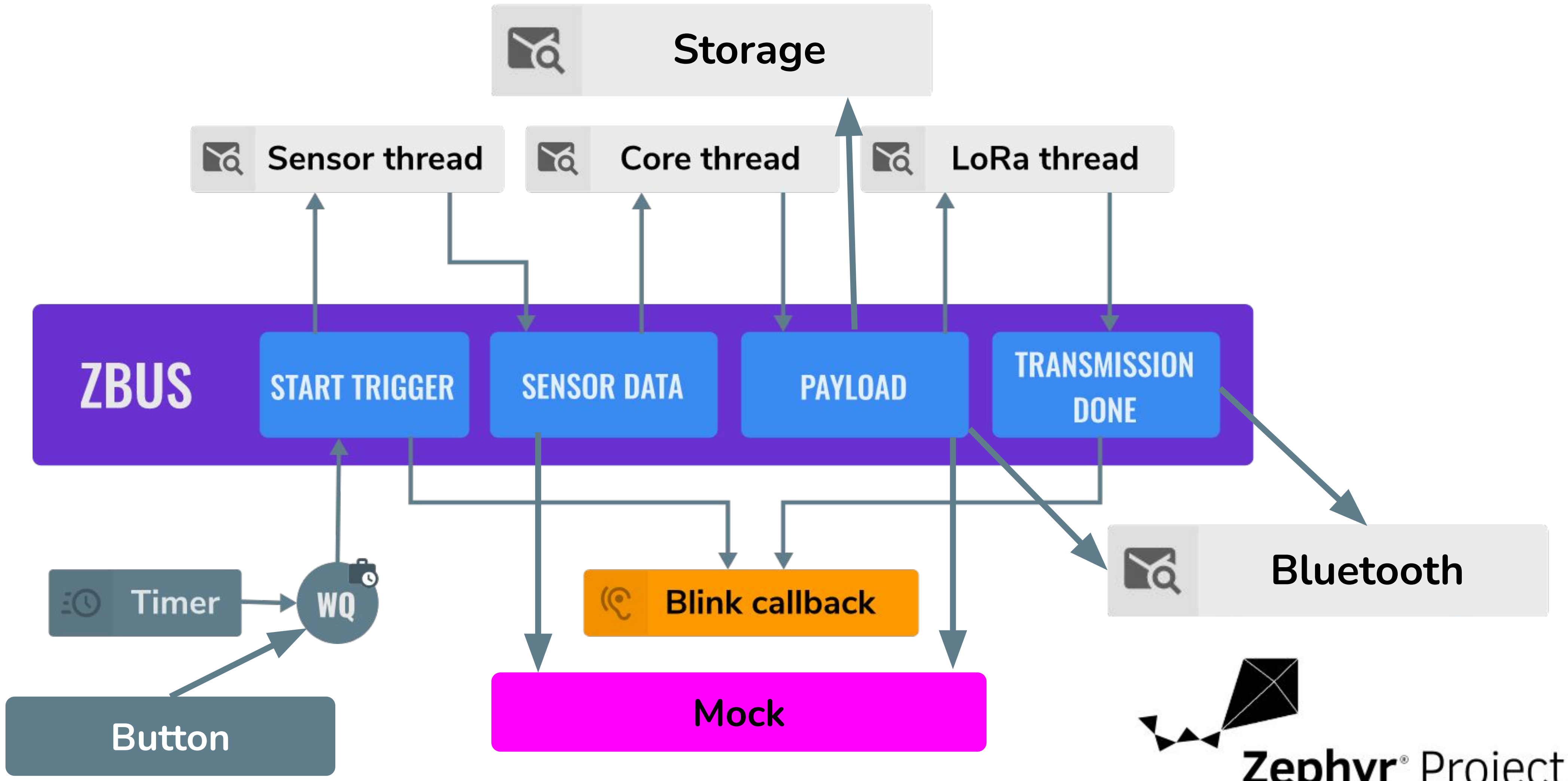
Button
Blink callback
Bluetooth

Example



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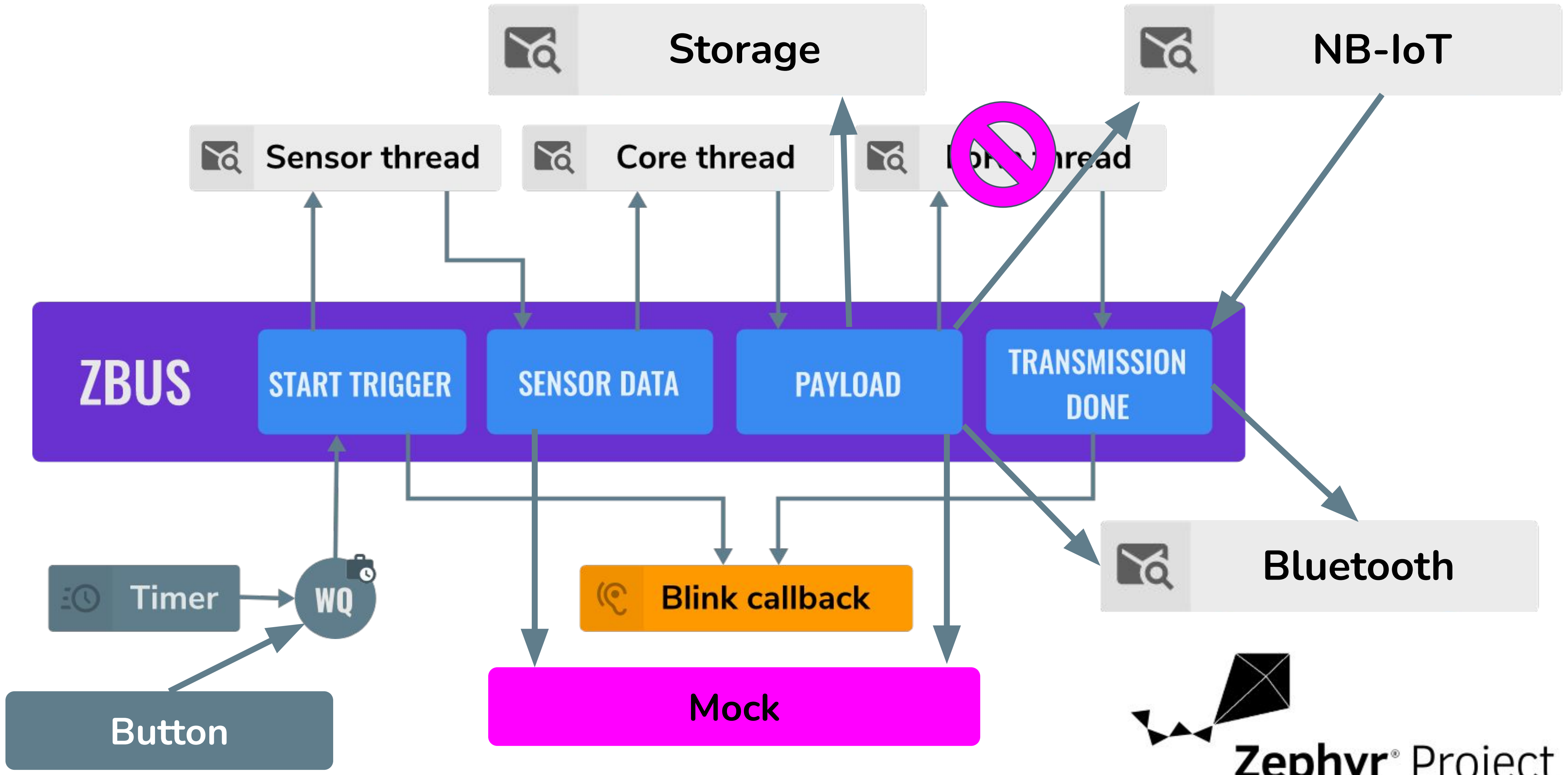
Example



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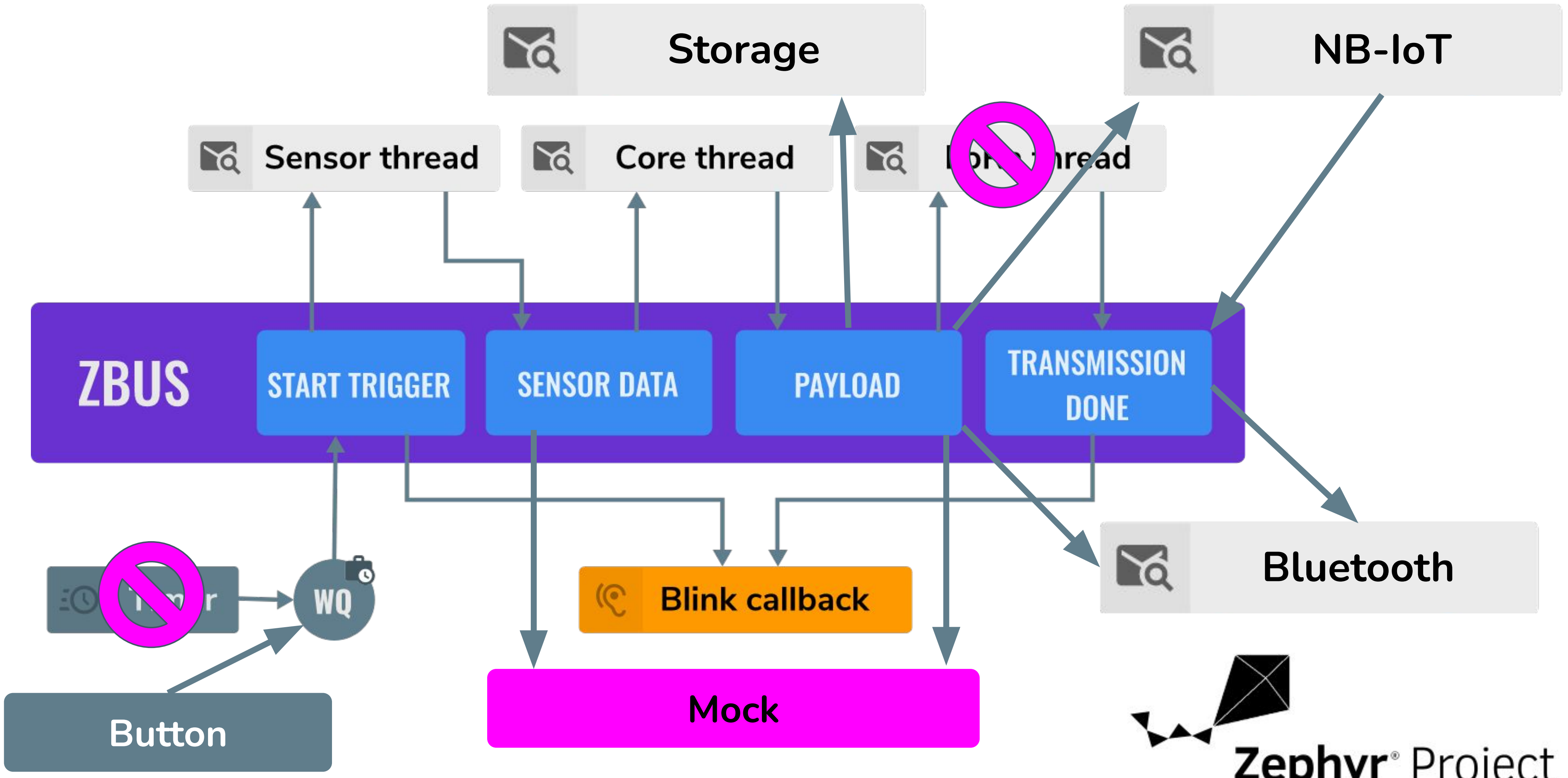
Example



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Usage considerations

PROS

- Promotes event-driven architecture
- Unified way to make threads talk and share data
- Code decoupling (time, space, and synchronization)*
- Promotes reuse
- Increase testability (+controllability +observability)
- Extensible (claim/finish + user_data)

CONS

- Take time to master it
    - Too many possibilities
- Not for intensive byte streaming
- No delivery guarantees for subscribers

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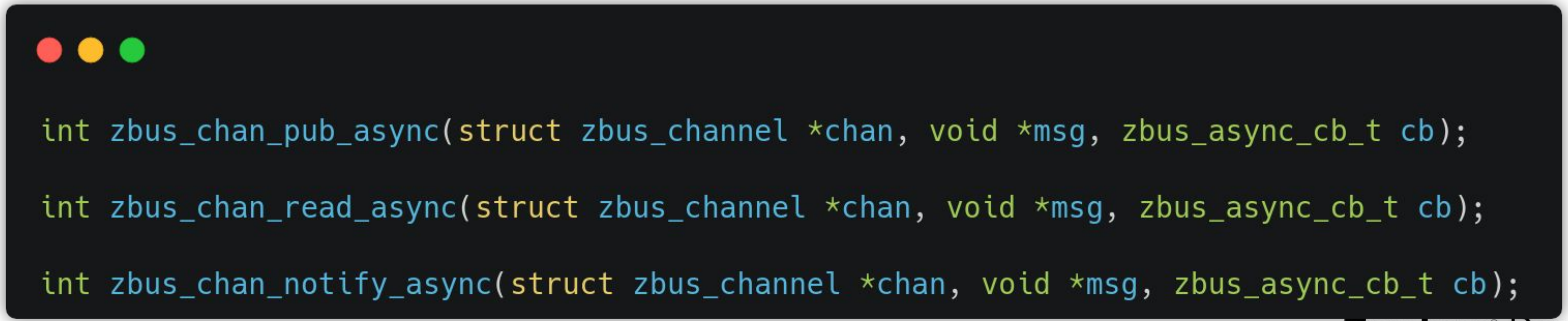
ZBus Features Backlog

ZBus async APIs

- Run inside an ISR could be possible
- Would avoid using work queues
- Dedicated ZBus thread



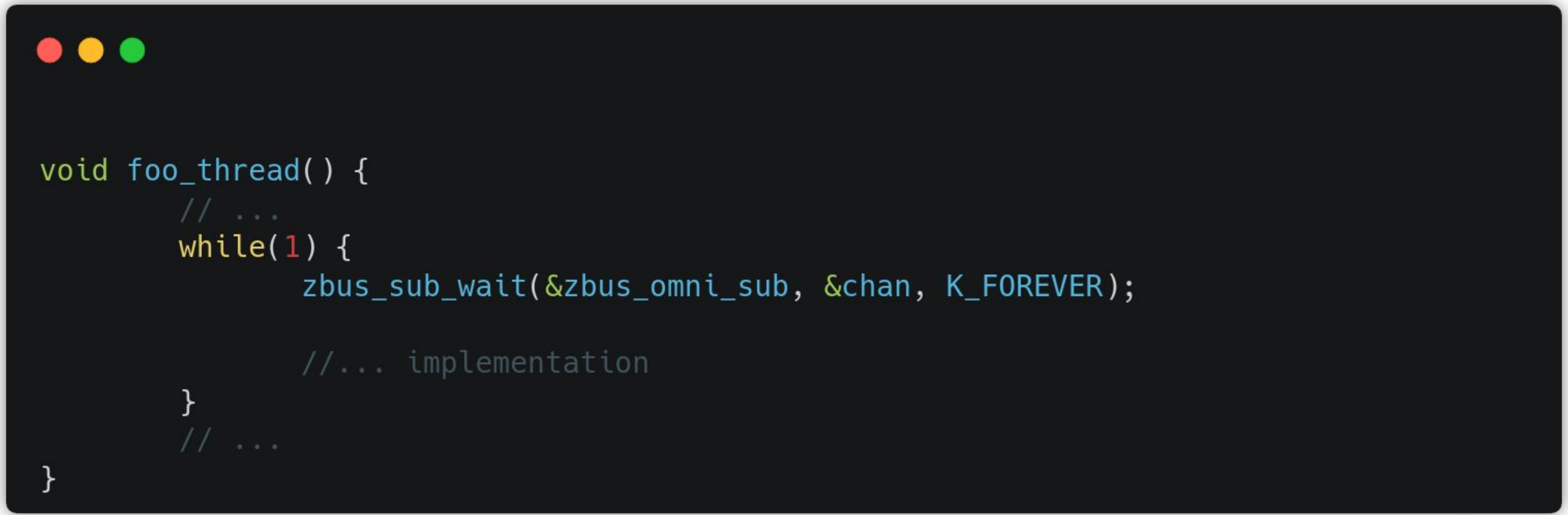
```c
int zbus_chan_pub_async(struct zbus_channel *chan, void *msg, zbus_async_cb_t cb);

int zbus_chan_read_async(struct zbus_channel *chan, void *msg, zbus_async_cb_t cb);

int zbus_chan_notify_async(struct zbus_channel *chan, void *msg, zbus_async_cb_t cb);
```

ZBus omni subscriber

- The omni subscriber will listen to all the channels
- It can be used to extend the bus features



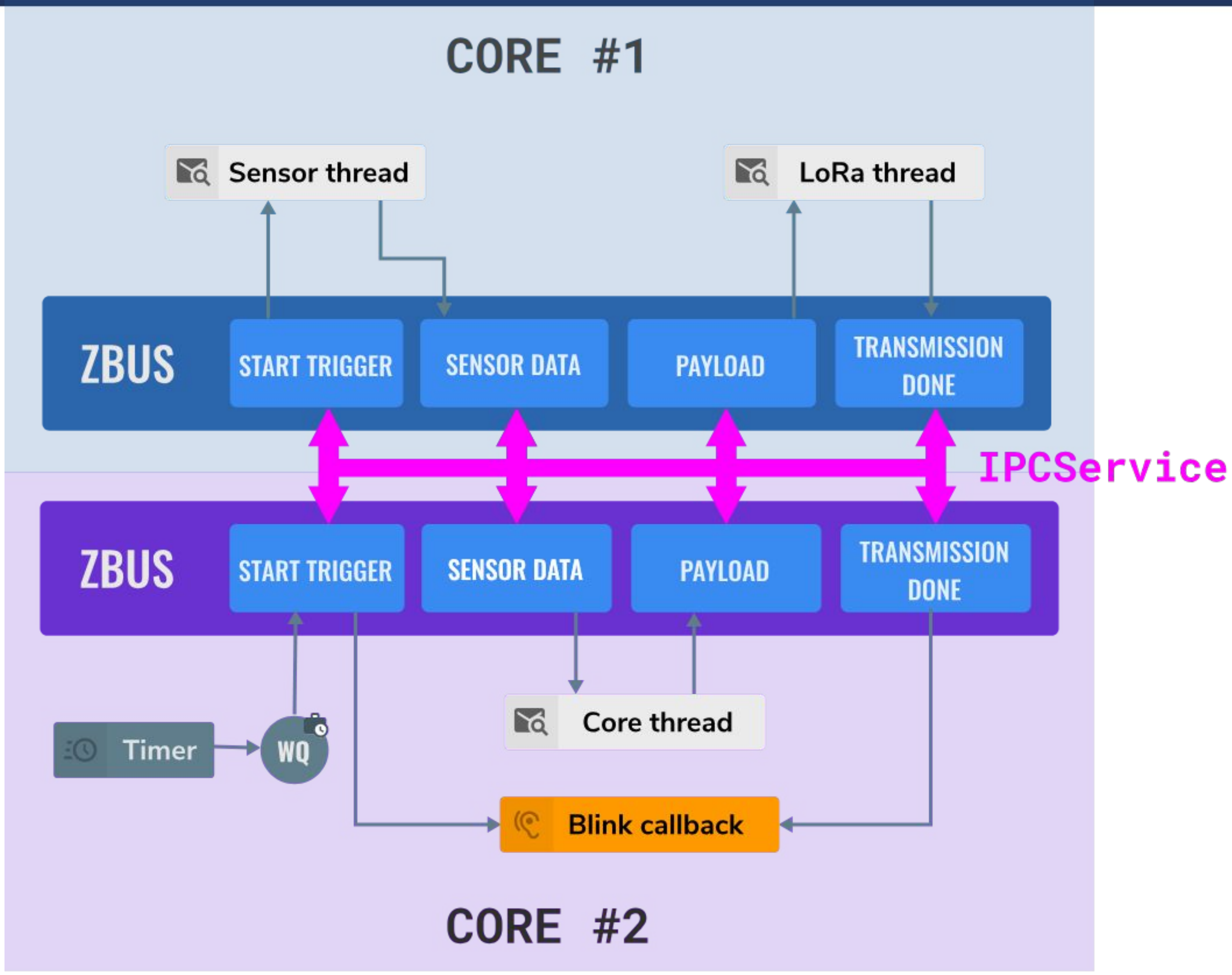
```
void foo_thread() {
        // ...
        while(1) {
                zbus_sub_wait(&zbus_omni_sub, &chan, K_FOREVER);

                //... implementation
        }
        // ...
}
```

Integration and samples

- Make ZBus an Input subsys event distributor backend
- Add samples (Bluetooth, Sensors, FSM, etc.)

ZBus for multi-core



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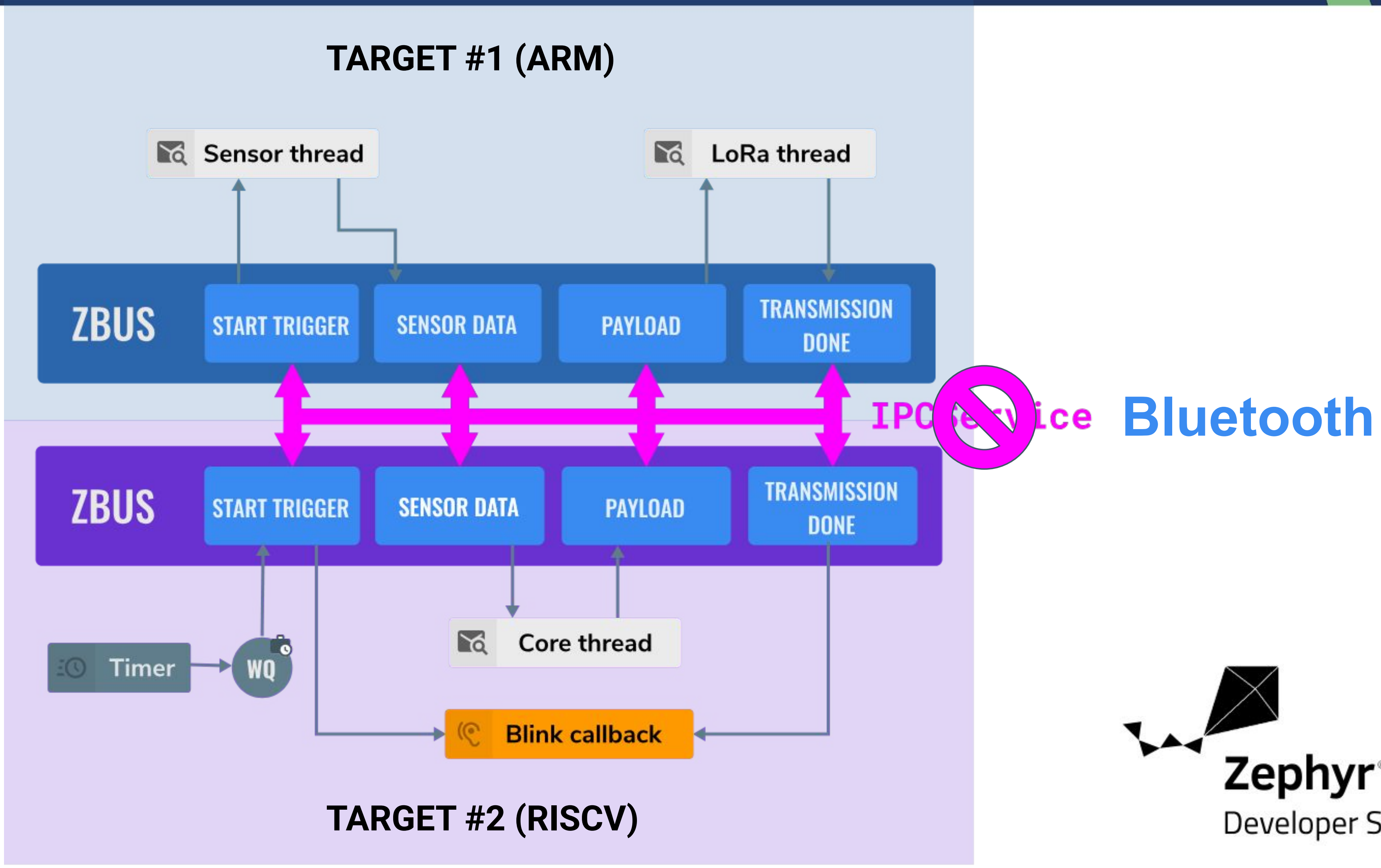
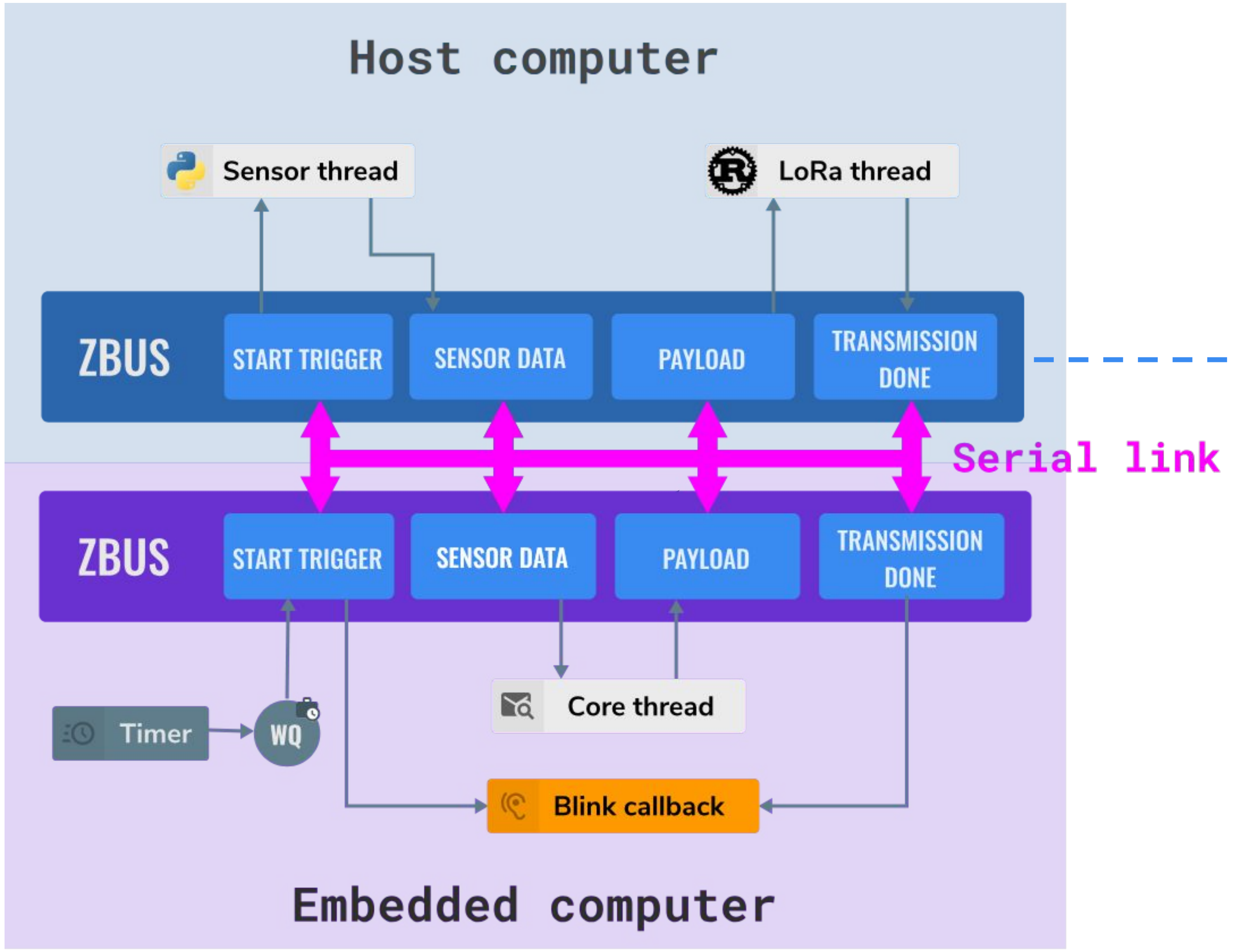
ZBus for multi-target



ZBus desktop



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ZBus Discord Channel

ZBus Roadmap topic at Zephyr Discord channel

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Tips and tricks

Listeners

❌ Avoid excessive use of them, they are running during the publishing process

❌ Do not sleep inside listeners. It will increase the publishing latency

✅ Think of them as an ISR. They must run as quickly as possible

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Listeners

✅ Use a work queue or separated thread instead of executing something heavy inside a listener

✅ Use **`zbus_chan_const_msg`** inside listeners. The channels are already locked!

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Subscribers

❌ Do not use subscribers when losses and duplications cannot be tolerated

✅ Use listeners in conjunction with message queues

✅ PR with confirmed channels sample submitted

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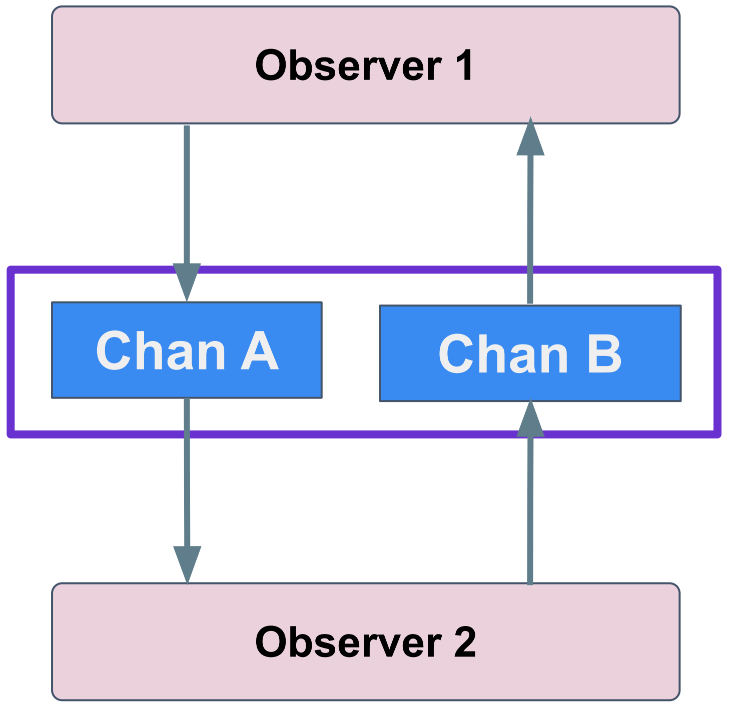
Undesired loops

❌ Take care with publishing loops

✅ Avoid loops on the bus diagram



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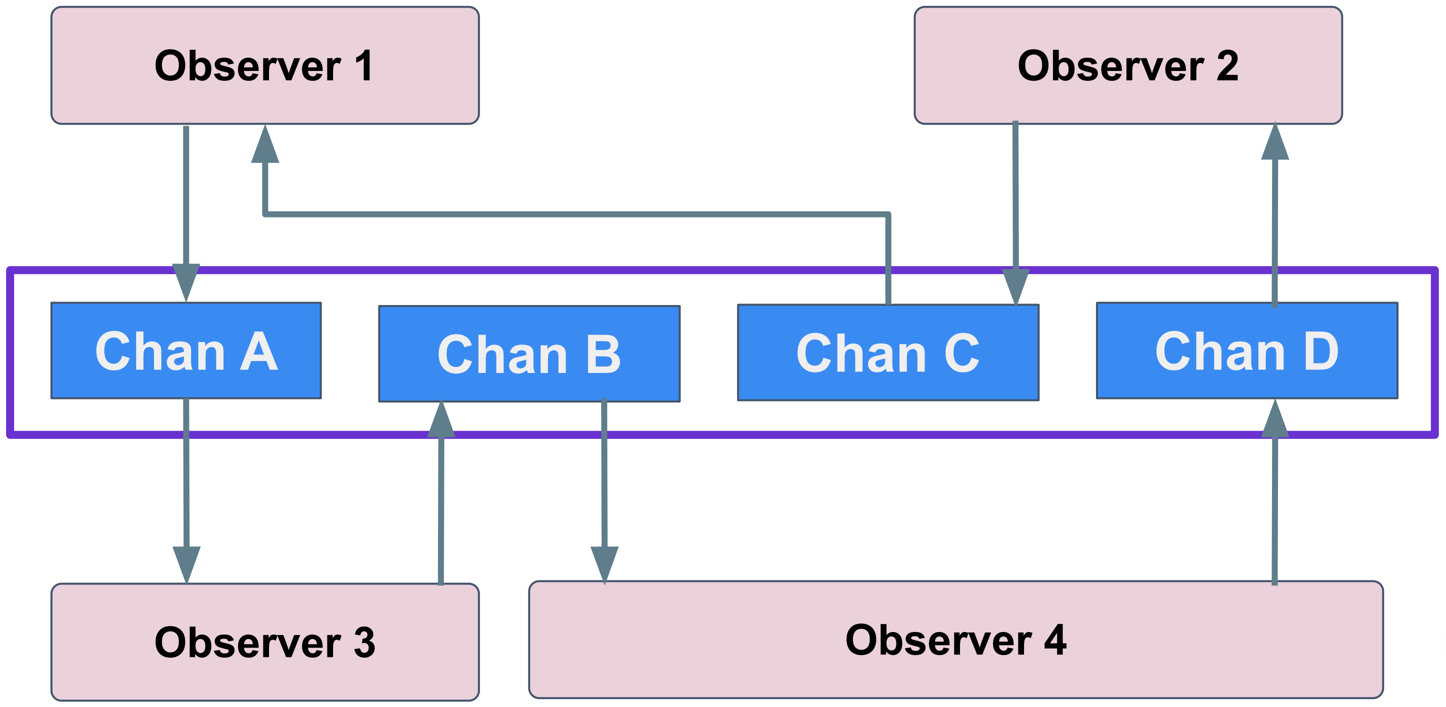
Undesired loops

❌ Take care with chained publishing loops



ISR

❌ Do not use ZBus functions inside an ISR

✅ Postpone that by using work queues instead

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Extras

- ✅ The channels can be used as a concurrent property system
- ✅ Isolate the hardware code using channels
- ✅ Use channels as modules interface [in/out]

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Questions & Answers

Thank you!