Embedded Software

A Message Distribution System

Agenda

- Current design
- Two approaches for decoupling
  - Specific receiver
  - Broadcasting - who the receiver is is irrelevant
- Singleton pattern
- In perspective
  - Publish/Subscriber schemes and coupling
  - Group and plenum discussion

Current design and next step

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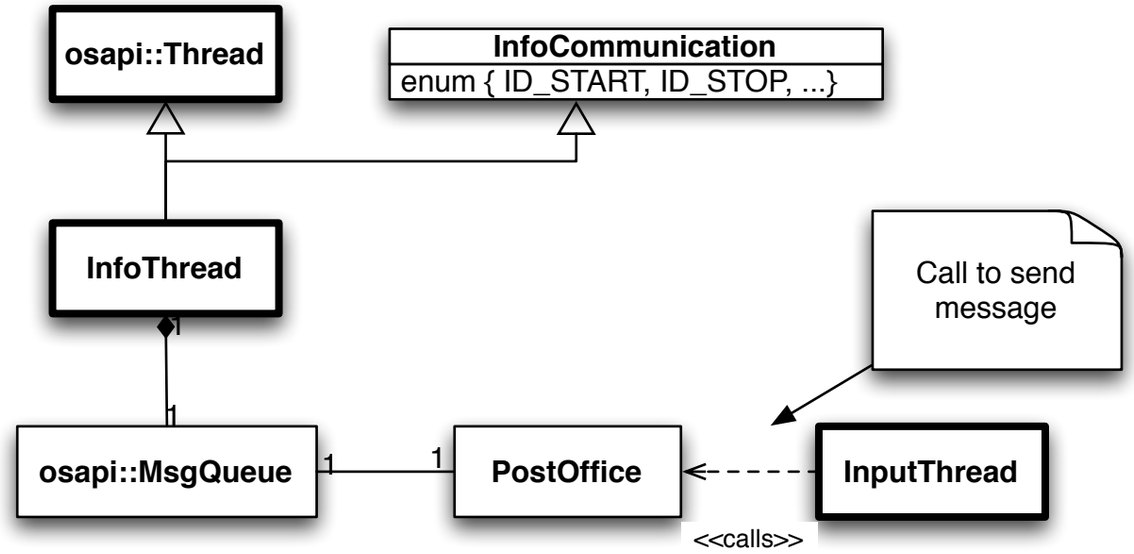
Current design

- A thread has a message queue through which other threads pass it messages
  - Consequence is that “other” threads need to have access to it’s message queue.
  - At application start these pointers (or references) must be passed around
- Problems - Potential Couplings issues
  - Challenges during creation - *chicken and the egg*
  - Leading to cyclic includes
  - Close relationships that are not needed

Design: Specific receiver



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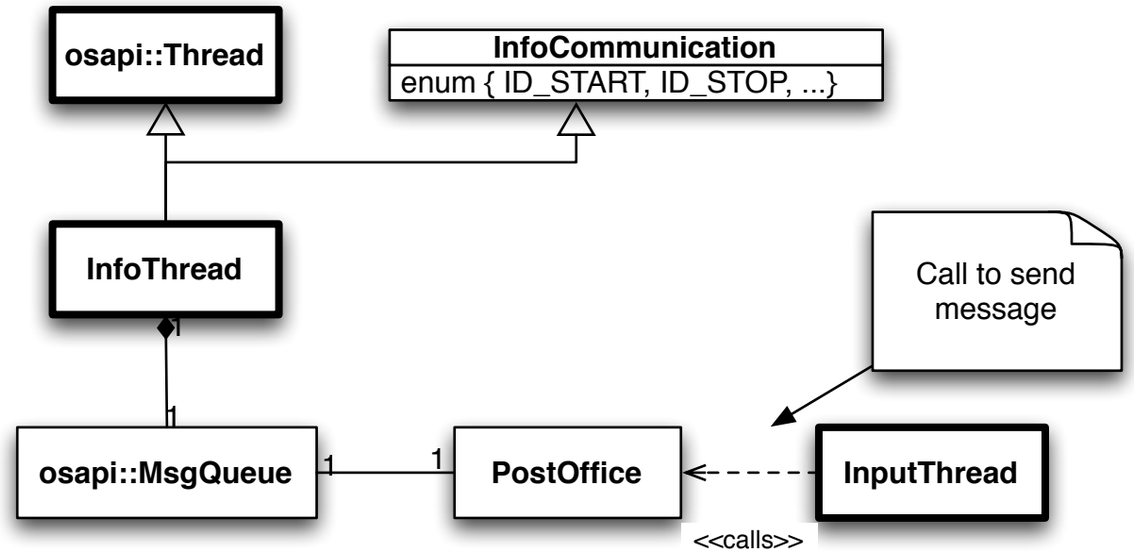

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  - Send messages by *naming* (string format) the recipient
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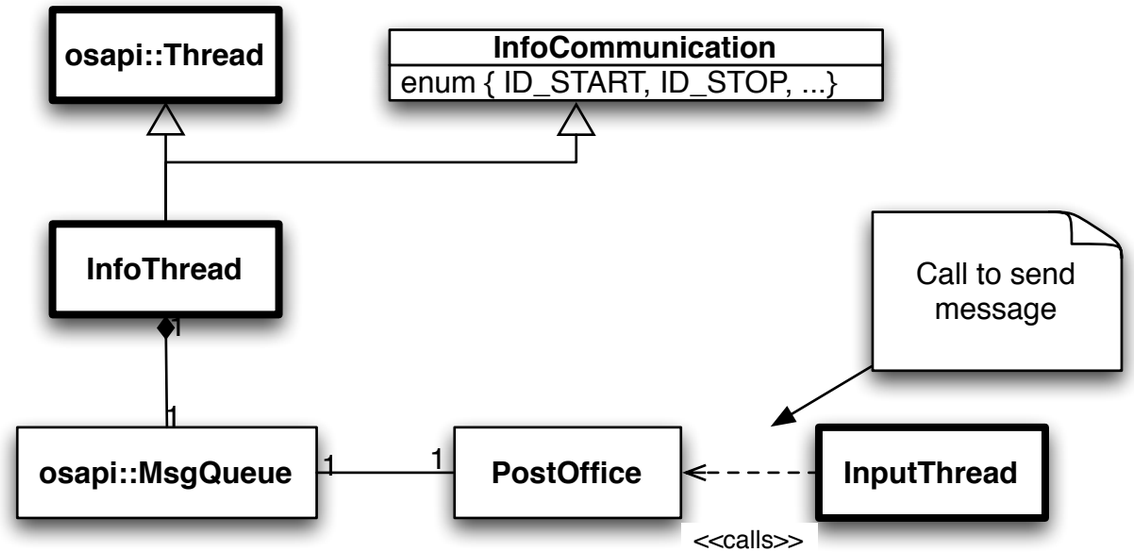

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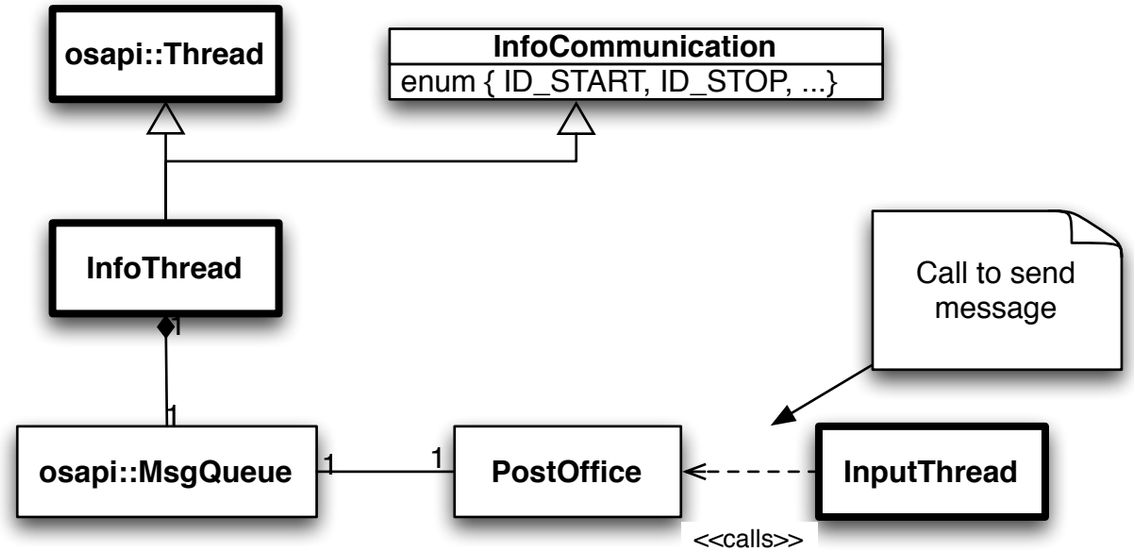

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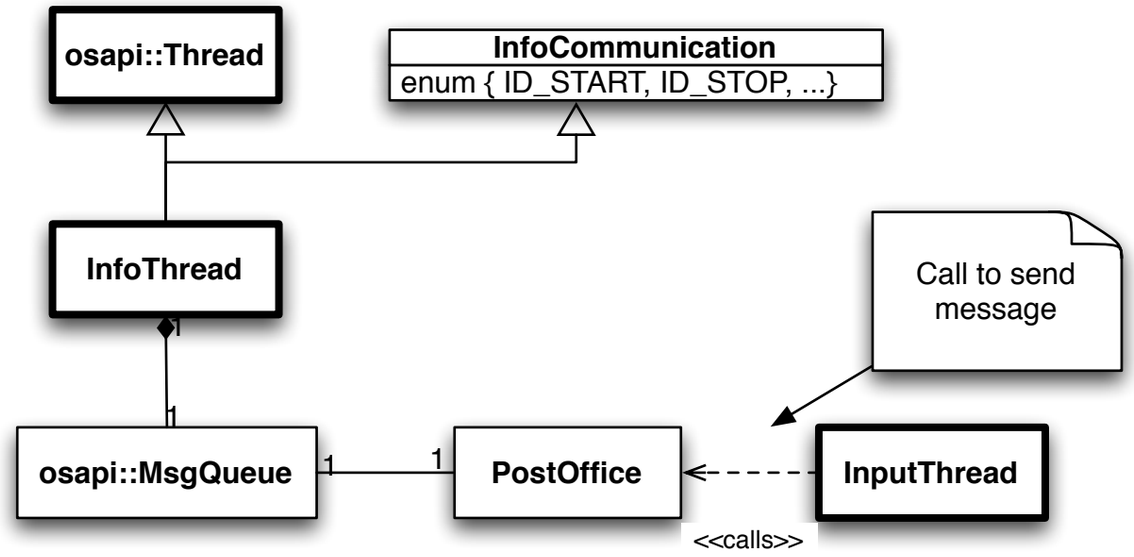

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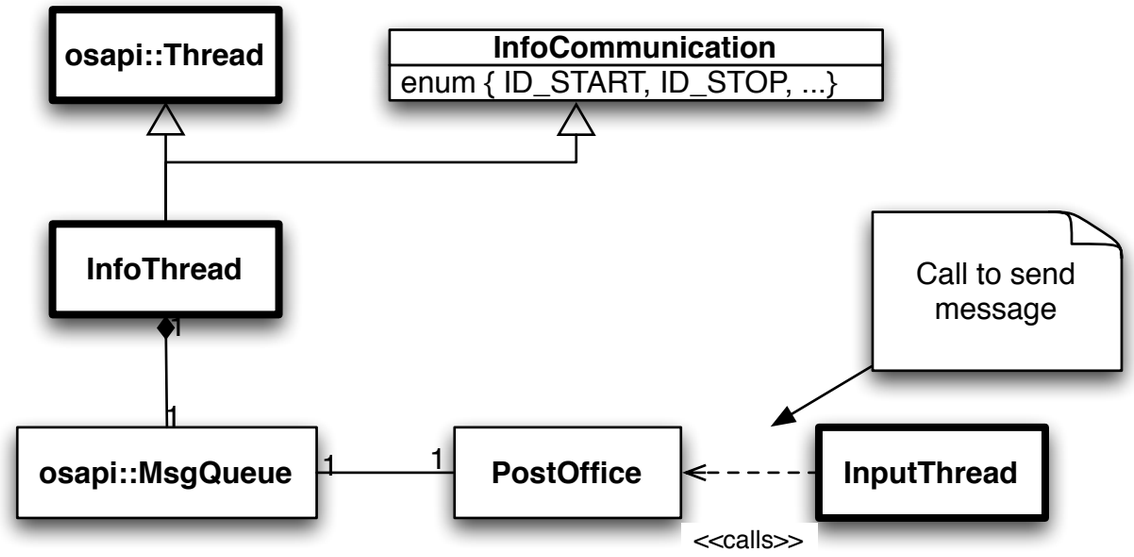

Design: Specific receiver - Example

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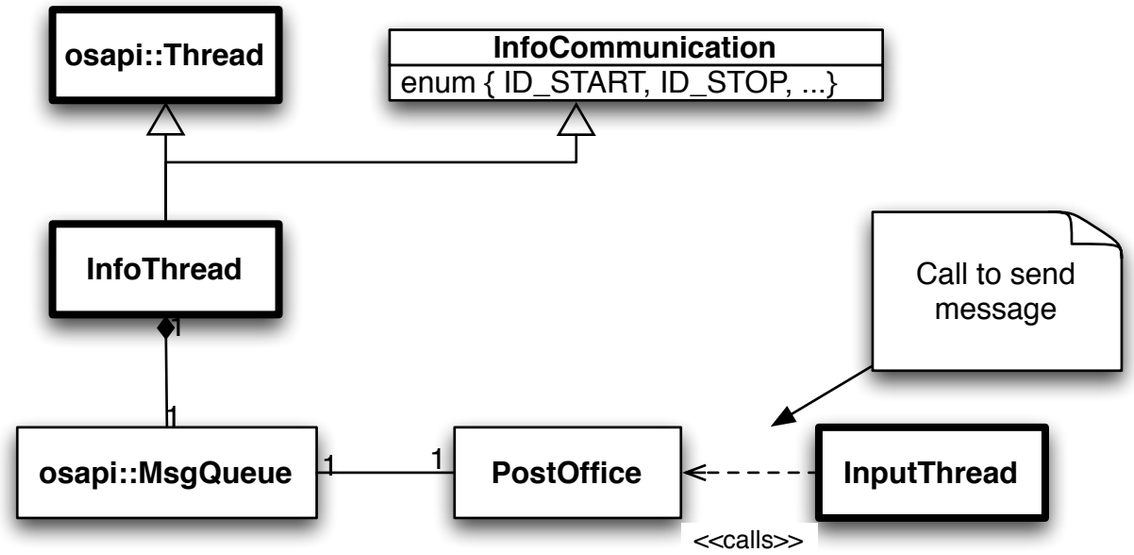

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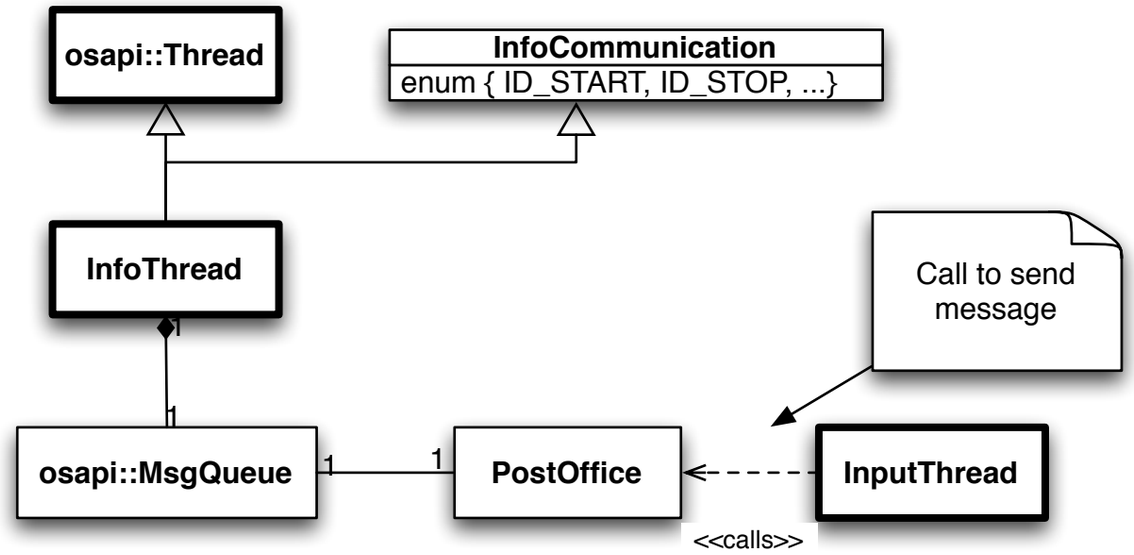


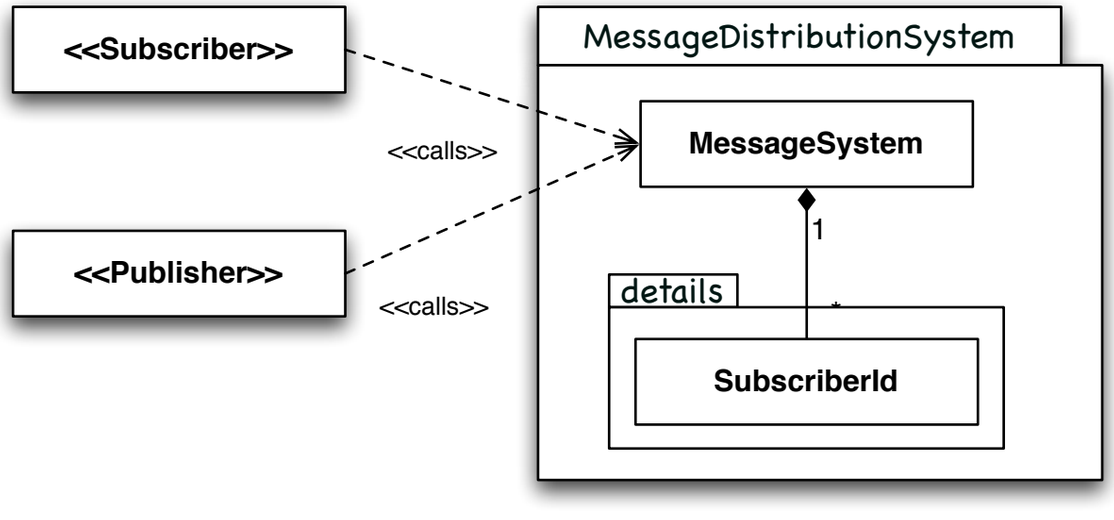

```
// InputCommunication.hpp
struct InputCommunication
{
    static const std::string QUEUE;
    enum { ID_START }
};

// In some thread...
#include "InputCommunication.hpp"

StartMsg* startMsg = new StartMsg;

PostOffice::send(InputCommunication::QUEUE, InputCommunication::ID_START, startMsg);
```

Design: Broadcasting - who the receiver is *is* irrelevant



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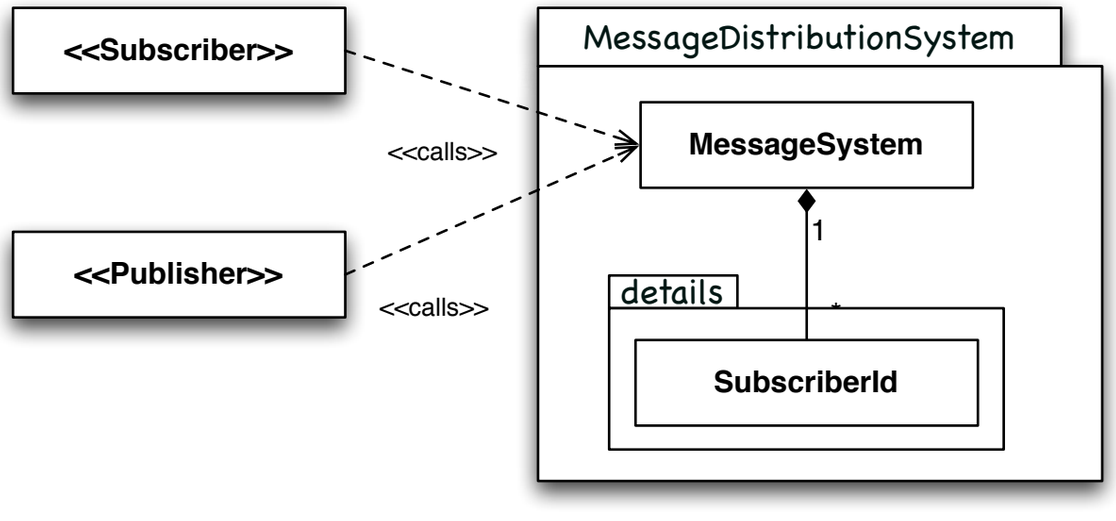
  - ID to receive when a message is ready



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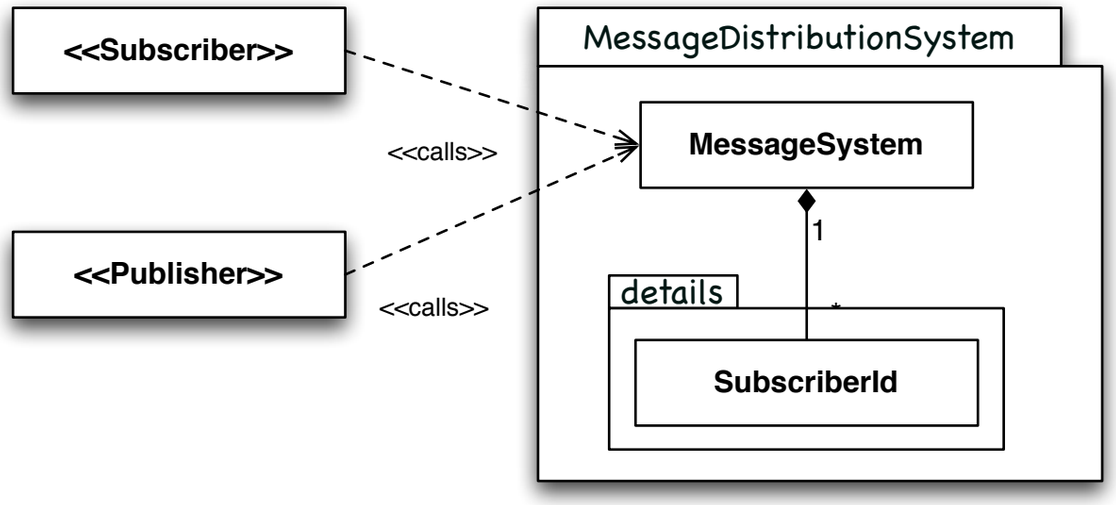
  - Notifies all subscribers (if any), each will receive the message being distributed with their own desired id



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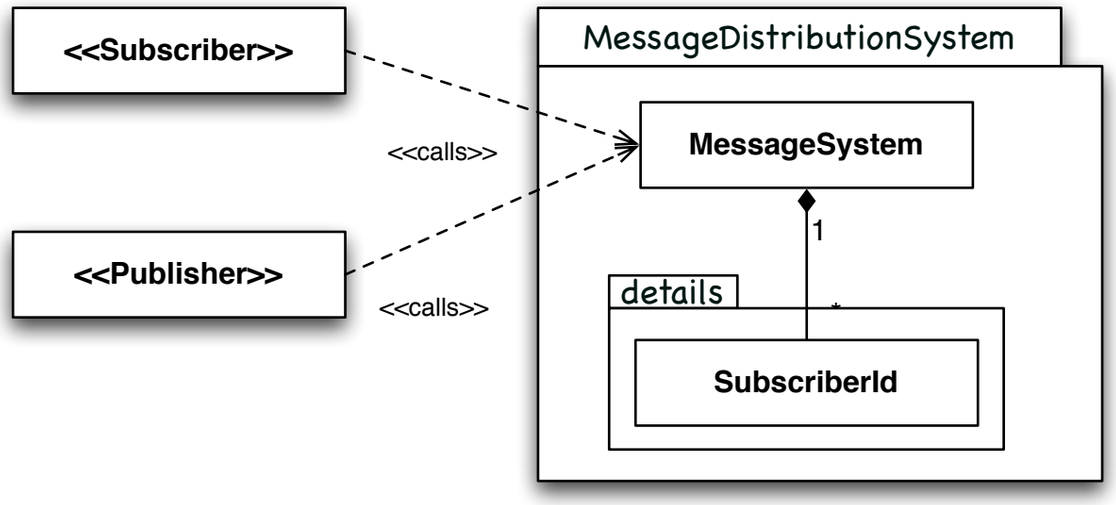

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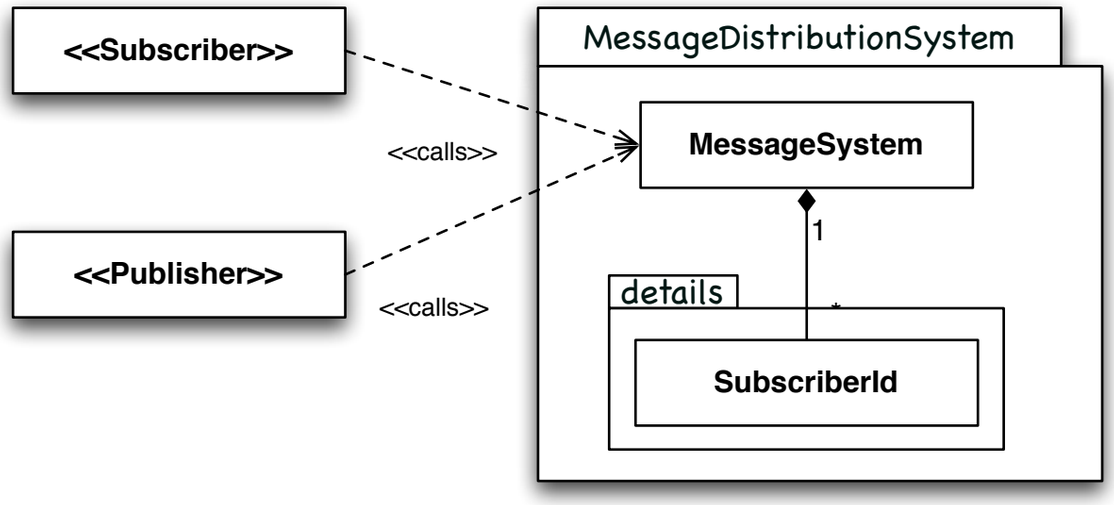
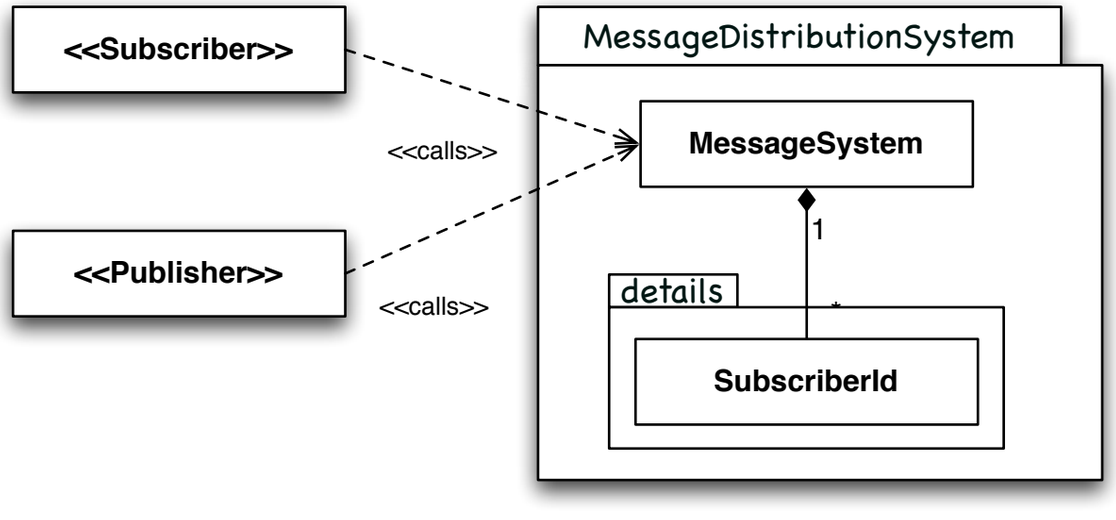


- Requires
  - A MessageDistributionSystem is up and running prior to use
  - Singleton usage or parsing around pointer/reference
  - Message ***Globally*** identifiable by string
  - One way communication

Design: Broadcasting - who the receiver is *is* irrelevant Example

- Simple example using the MessageDistributionSystem directly



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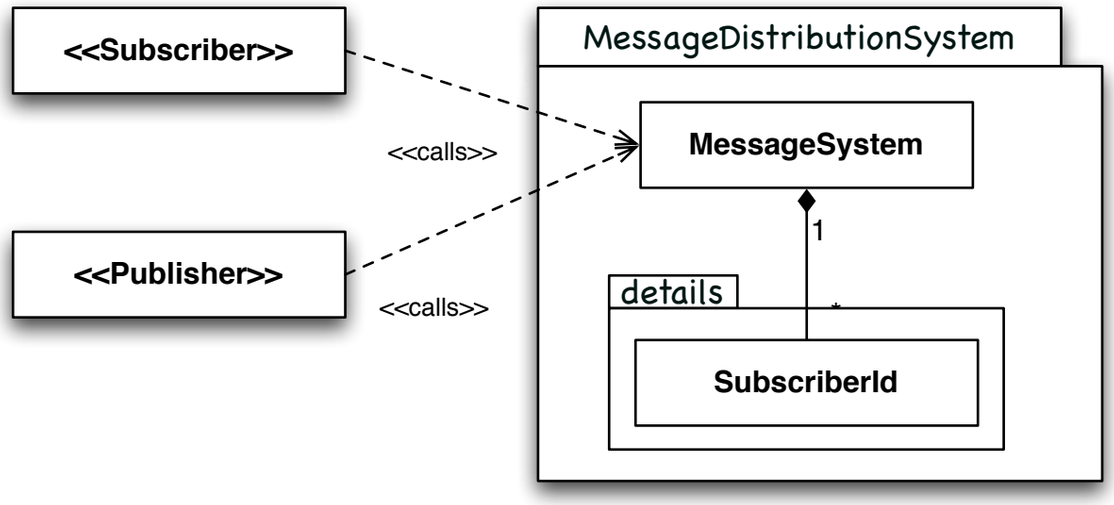


```
// Subscriber
MessageDistributionSystem::getInstance().subscribe(START_MSG, &mq_, ID_START);
...

void handleMsg(id, msg)
{
    switch(id_)
    {
        case ID_START:
            handleIdStart(msg);
    }
}

// Publisher
MessageDistributionSystem::getInstance().notify(START_MSG, startMsg);
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// hpp - file
struct StartMsg : public osapi::Message
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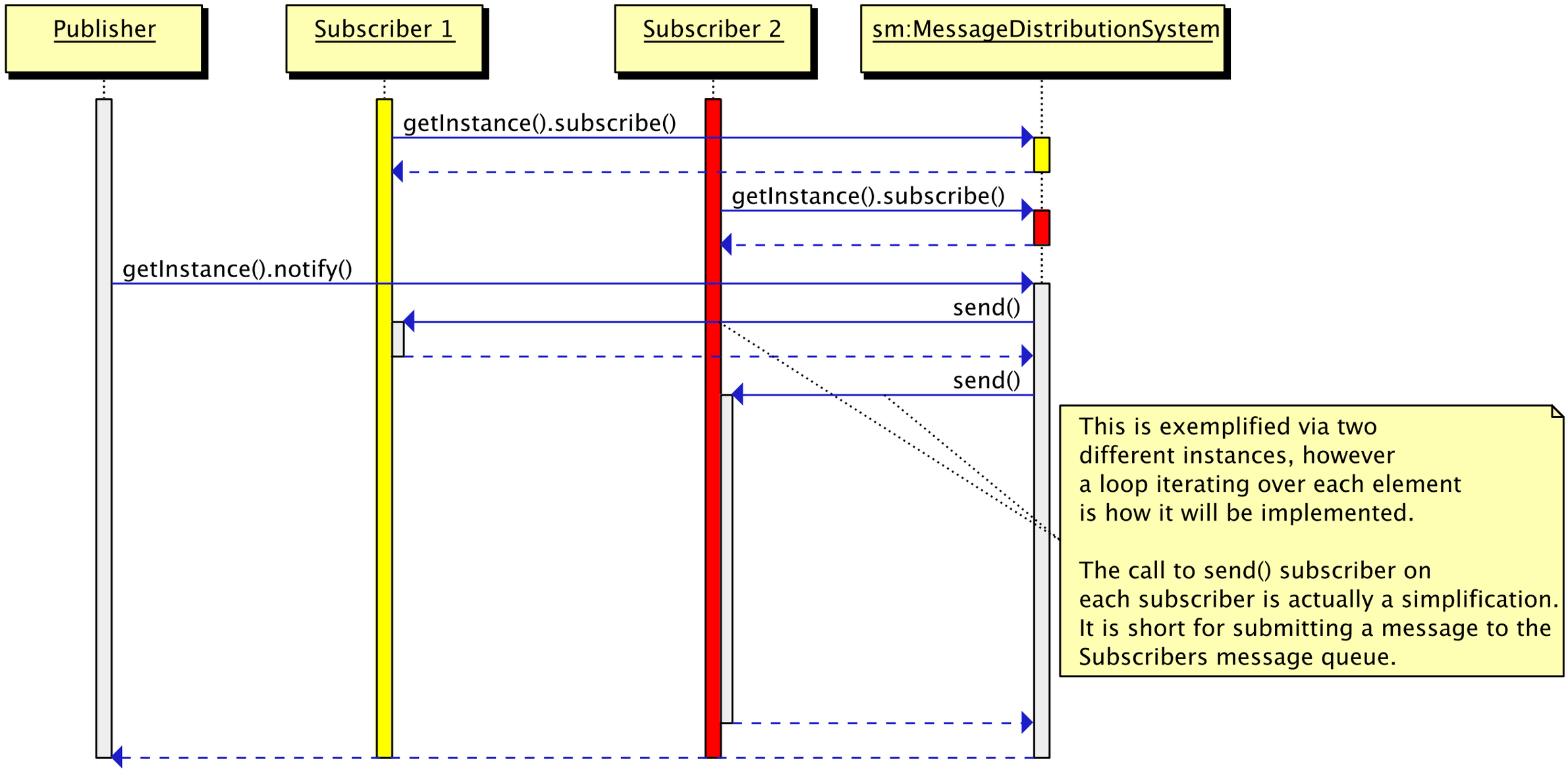

This is exemplified via two different instances, however a loop iterating over each element is how it will be implemented.

The call to send() subscriber on each subscriber is actually a simplification. It is short for submitting a message to the Subscribers message queue.

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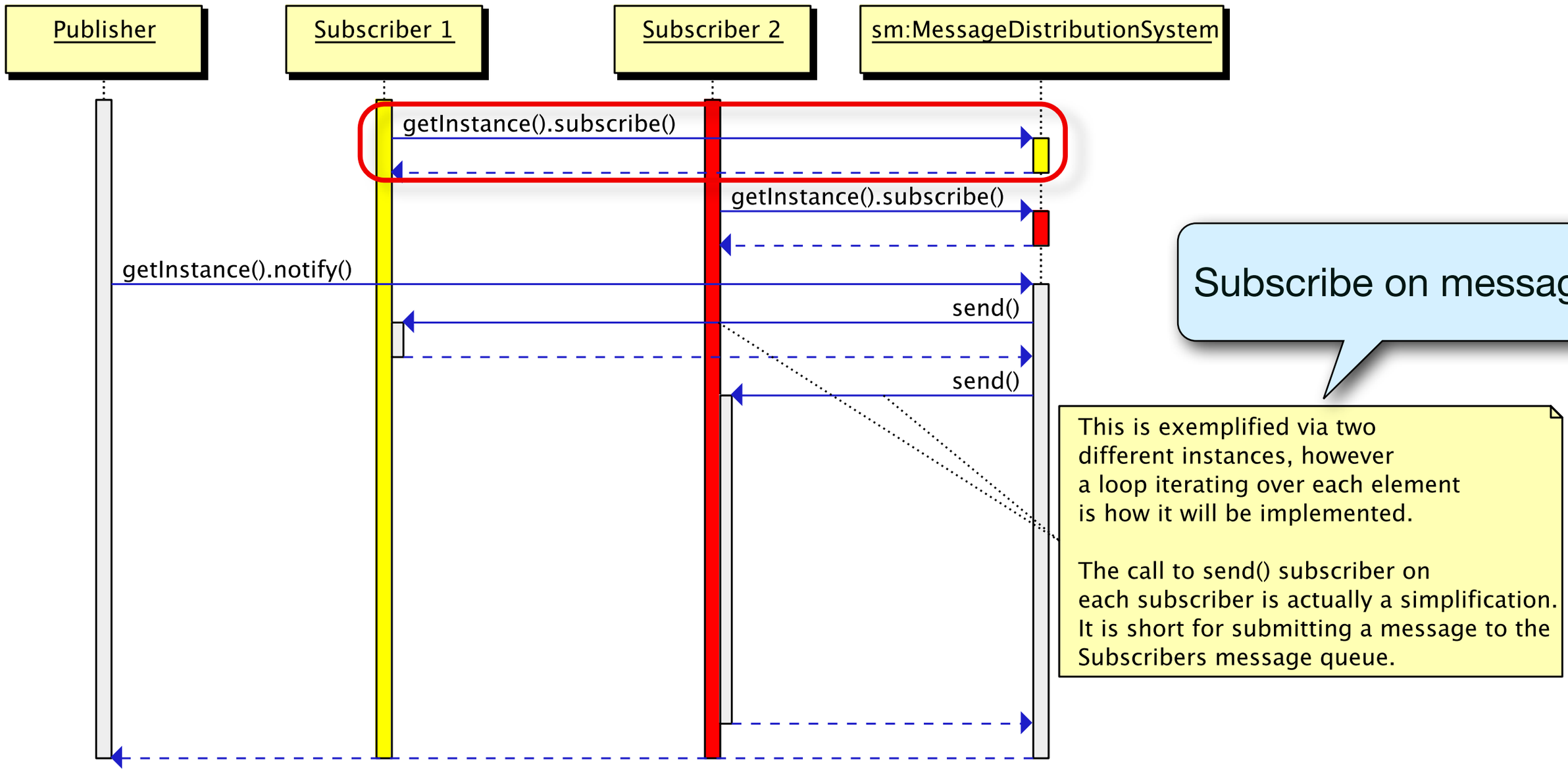

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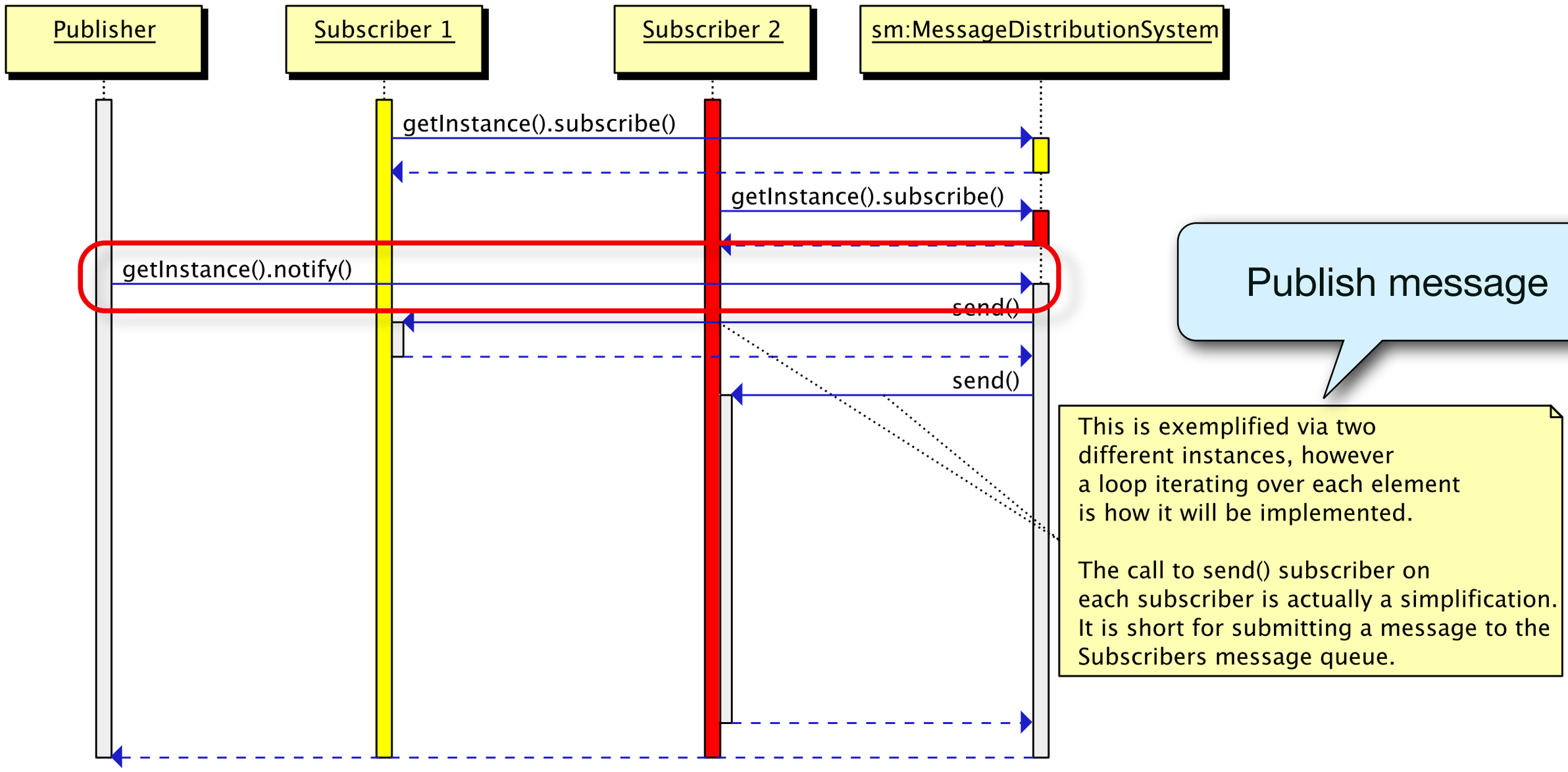

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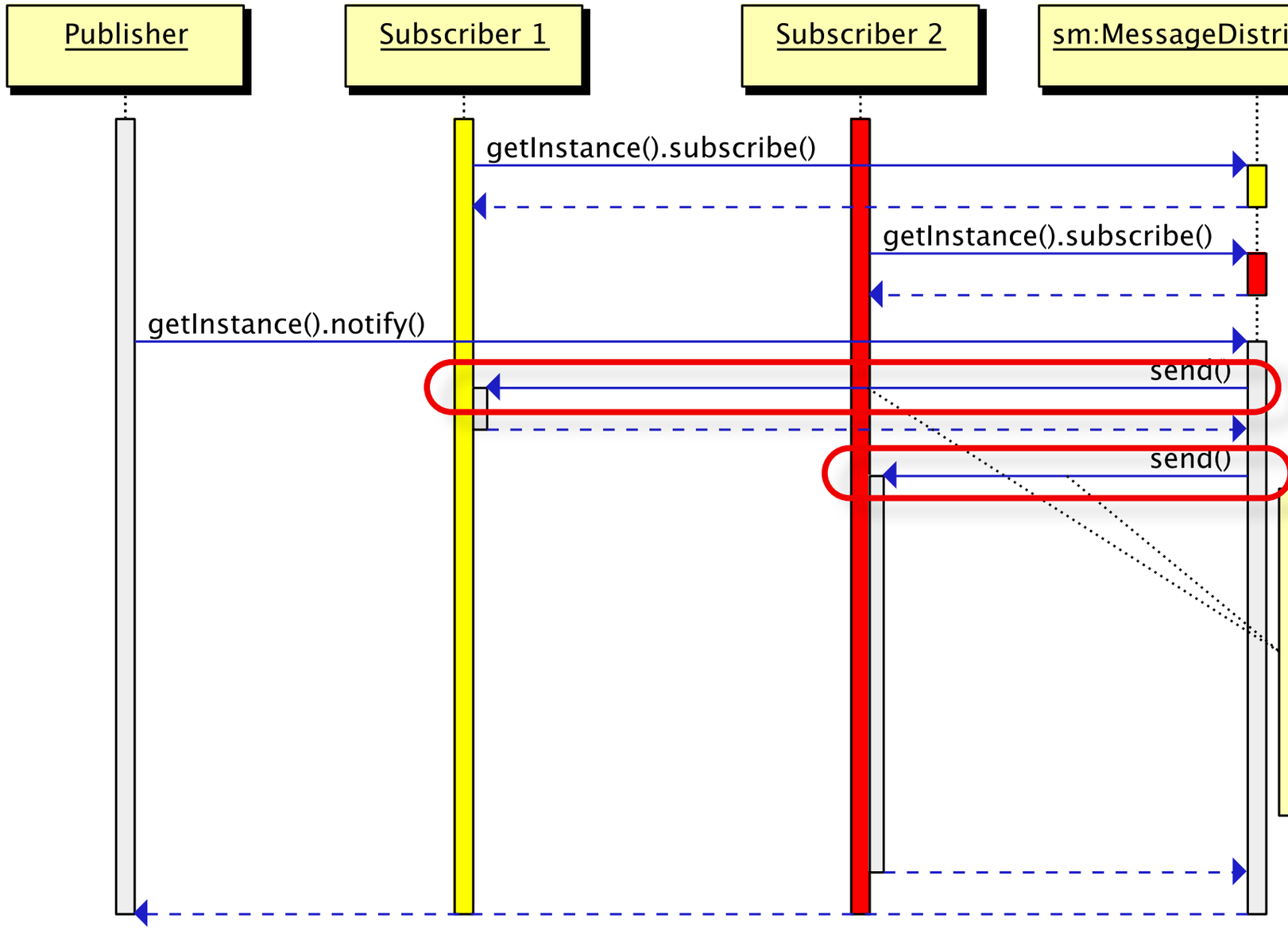

MSD notifies all

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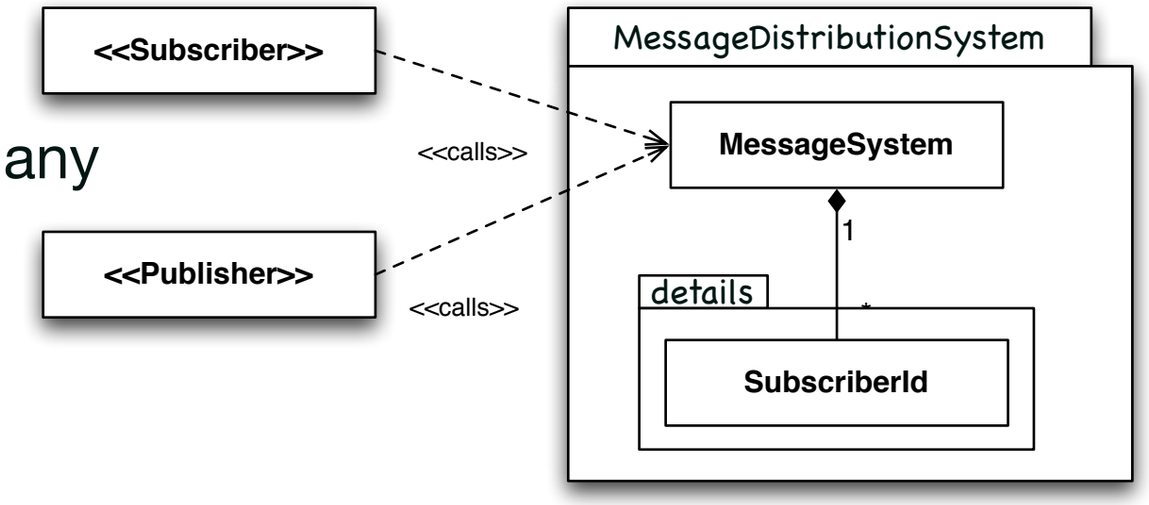
In this scenario - we choose...

- **Broadcasting - Who the receiver is *is* irrelevant**
  - One way communication
  - Knowledge of each other irrelevant
  - Lower coupling
- Usage scenarios
  - Indication that something has happened
    - Log entry
    - New temperature value

Singleton

Singleton pattern

- Challenge
  - System wide access to a given object ⇒Many pointers and/or references to be passed around
- Possible solution
  - ***Singleton***
- Usage could be
  - Message Distribution System
  - Config service
  - Log service
  - Any kind of application wide service



- Downsides
  - Global variable like
    - Serialized access needed
  - Lifetime
    - Who creates?
    - Who destroys and when?

Singleton pattern - Example

- Simple code example using the *static block initialization* approach
- Good
  - First access creates
  - Extremely easy to code and understand
  - No locks (in our approach)
- Downsides
  - First access creates - Multithreaded challenge
- Beware of “The double-checked locking” idiom
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```
// Singleton
class MessageDistributionSystem : osapi::NotCopyable
{
public:
    void subscribe(const std::string& msgId,
                   osapi::MsgQueue* mq, unsigned long id);
    void unSubscribe(const std::string& msgId,
                     osapi::MsgQueue* mq, unsigned long id);

    MessageDistributionSystem& getInstance()
    {
        MessageDistributionSystem mds;
        return mds;
    }

};

// Subscriber
MessageDistributionSystem::
       getInstance().subscribe(START_MSG, &mq_, ID_START);
```

Reflection - In perspective

Reflection - In perspective

- In relation to existing approaches - how does our choice fair?
  - Coupling
  - Publish/Subscriber schemes

- Group discussion followed by a plenum discussion

Decoupling

- Space decoupling
  - No references nor knowledge of each other
  - Number of subscribers not known
- Time
  - Do not need to be “online” at the same time
- Flow
  - Publishers are not blocked while creating messages
  - Subscribers do not *pull* new messages in a synchronously manner

Alternative schemes

- Topic-based
- Content-based
- Type-based

Topic-based scheme

- Idea
  - Identification/Key via a String
  - Topic abstraction
    - *topic == hierarchical addressing (recursive possible)*
  - Subscription via URL-like notation
    - “Msg:/system/input/*”
    - Possible to use wildcards
- Additional
  - Simplified Topic - Group abstraction
    - Group == flat addressing

Content-based scheme

- Idea
  - Identification/Key via properties (filtering)
    - String
      - name - value pairs - “device == ‘engine’ and temp > 90”
    - Template object
      - All attributes that match - wildcards are ignored
  - Executable code
    - Predicate implemented by developer
    - Created using *method value* pattern

Type-based scheme

- Idea
  - Identification/Key via type - E.g. you register a specific type and thus filter by it
  - Any instances of this type *or* derived instances will be received as well (recursive like)
  - Requires *static type system* - Types bound at compile time

Your task

- Consider the “The Message Distribution System” in groups of 2-3 for 5mins
  - Coupling wise?
    - Consider what we had and what we have now - What have we achieved?
  - Publish/Subscriber scheme variation
    - Which fits over approach best
- Discussion of what it is...

Summary

- Message Distribution System
- Singleton
- Reflection on our choice and setting it into perspective

Minute Paper

- Send me an email containing (deadline is today)
  - What you thought was important from todays lecture
  - What you didn’t quite get

- Do this in your respective groups
- I will collect and if needed elaborate on next meet