CON3449

The Open Monolith

Keeping Your Codebase (and Your Headaches) Small

Michael Bar-Sinai
@michbarsinai
mbarsinai.com

Matthew Dunlap
@disbliss
sbgrid.org/about/staff/

@dataverseorg

Large, monolithic codebase is hard to work with.

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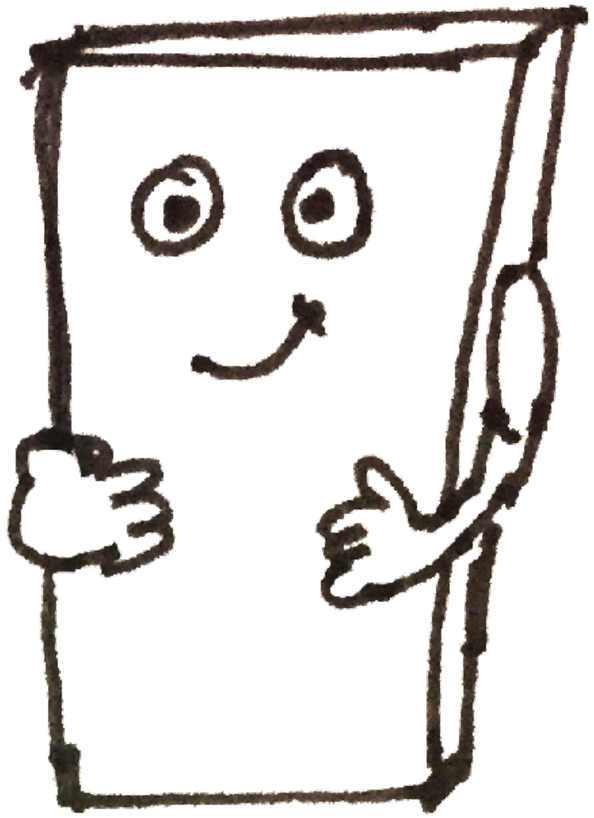
also, microservices are the new cool toy

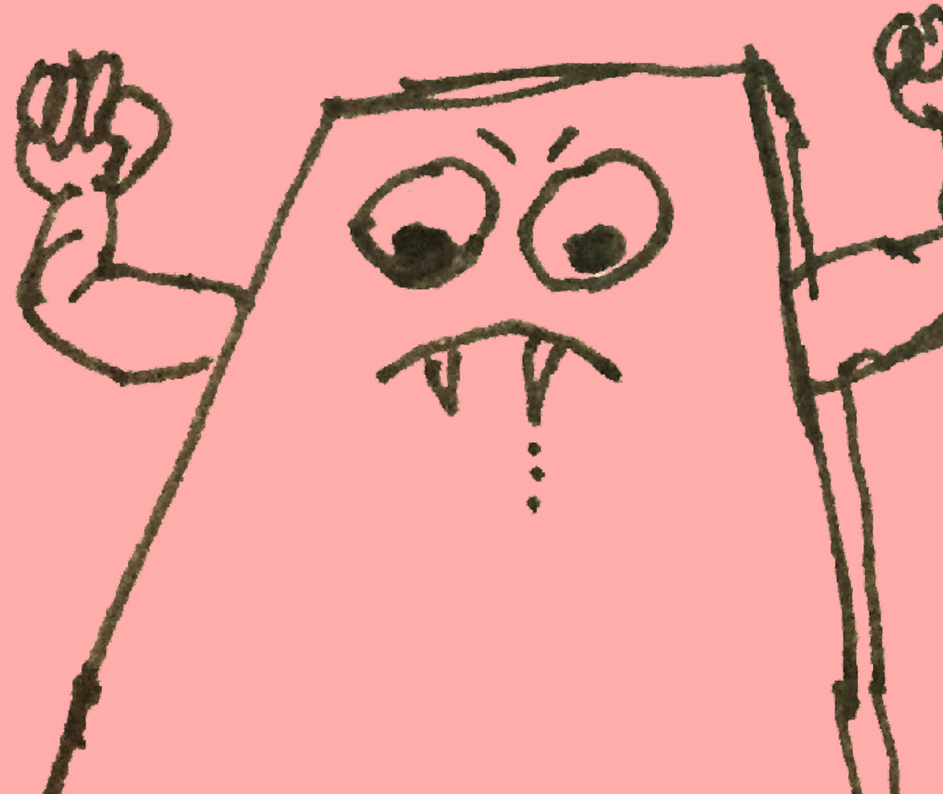
Monolith is Fun…

- Easy setup
- Entire system is versioned together
- **Static Typing** provides strong guarantees for compatibility between sub-systems.



…Until it becomes Too Large

- Adding new features becomes slower
- Updating existing features becomes harder
- Regressions become common



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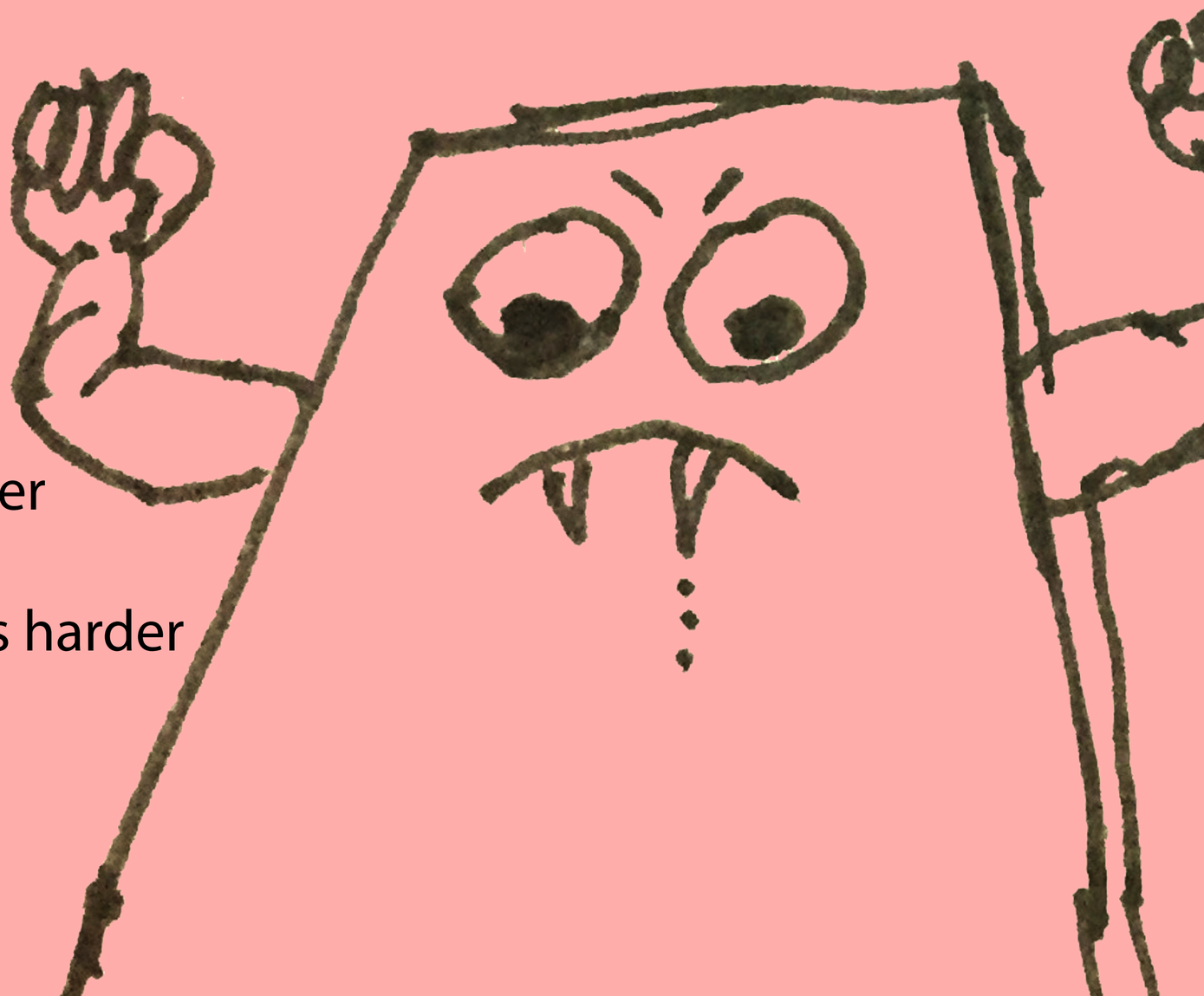

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Microservices are No Silver Bullet

- Application Re-write
- Re-arrangement of the production environment
- Complexity still there, but distributed
- Added overhead for network, versioning, deployment
- More resilient, better throughput, etc.

Is there a middle way between monolith and microservices?

Can we break the codebase,
but not shatter it to little pieces?

Harvard Dataverse

https://dataverse.harvard.edu

Dataverse

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Dataverses (2,346)

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Files (352,782)

Dataverse Category

Research Project (712)

Researcher (670)

Organization or Institution (194)

Journal (123)

Research Group (62)

More...

Metadata Source

1 to 10 of 77,005 Results

Sort

Replication Data for: Pivotal Politics and the Ideological Content of Landmark Laws"

Oct 2, 2017 - Journal of Public Policy Dataverse

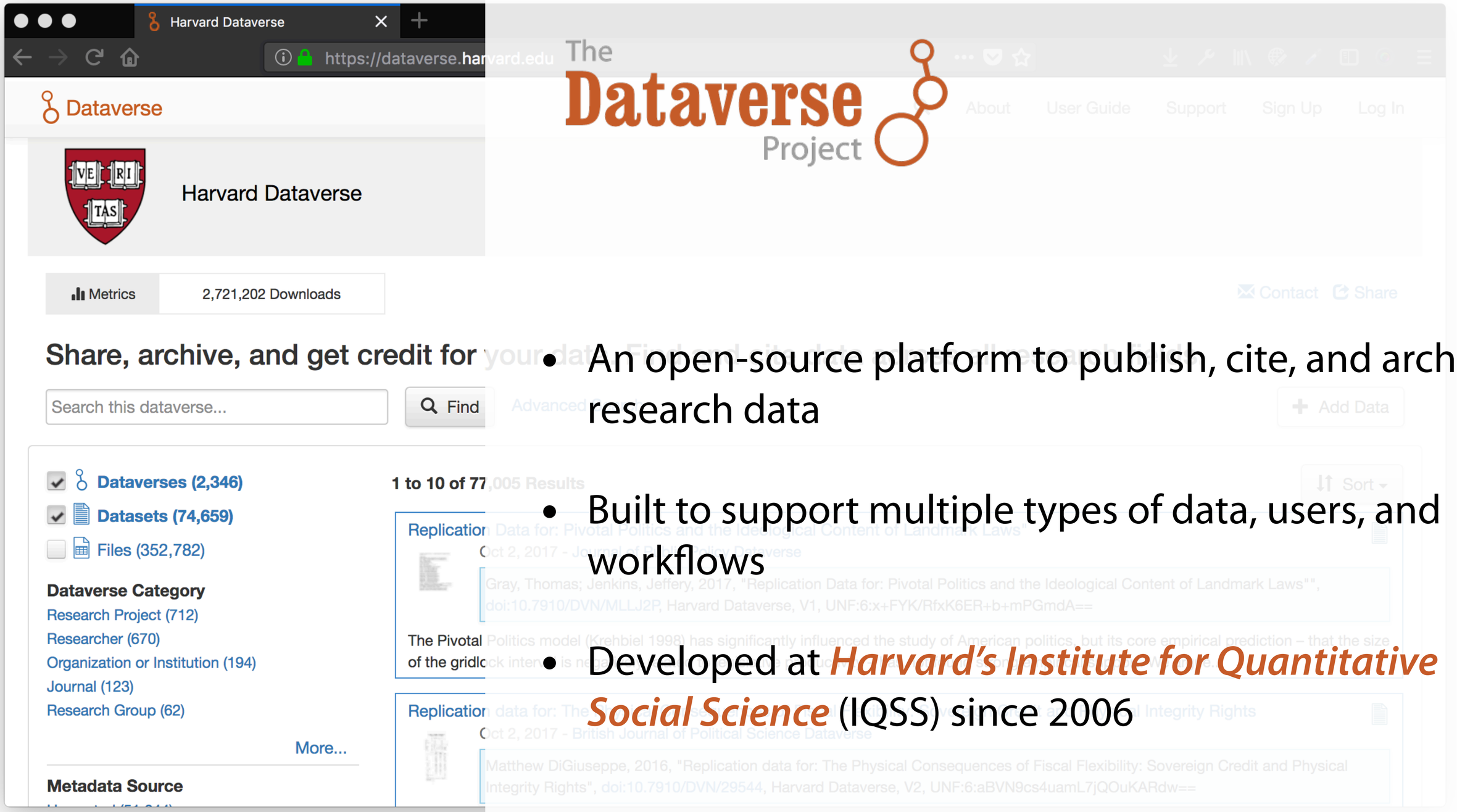
Gray, Thomas; Jenkins, Jeffery, 2017, "Replication Data for: Pivotal Politics and the Ideological Content of Landmark Laws"", doi:10.7910/DVN/MLLJ2P, Harvard Dataverse, V1, UNF:6:x+FYK/RfxK6ER+b+mPGmdA==

The Pivotal Politics model (Krehbiel 1998) has significantly influenced the study of American politics, but its core empirical prediction – that the size of the gridlock interval is negatively related to legislative productivity – has not found strong empirical support. We argue...

Replication data for: The Physical Consequences of Fiscal Flexibility: Sovereign Credit and Physical Integrity Rights

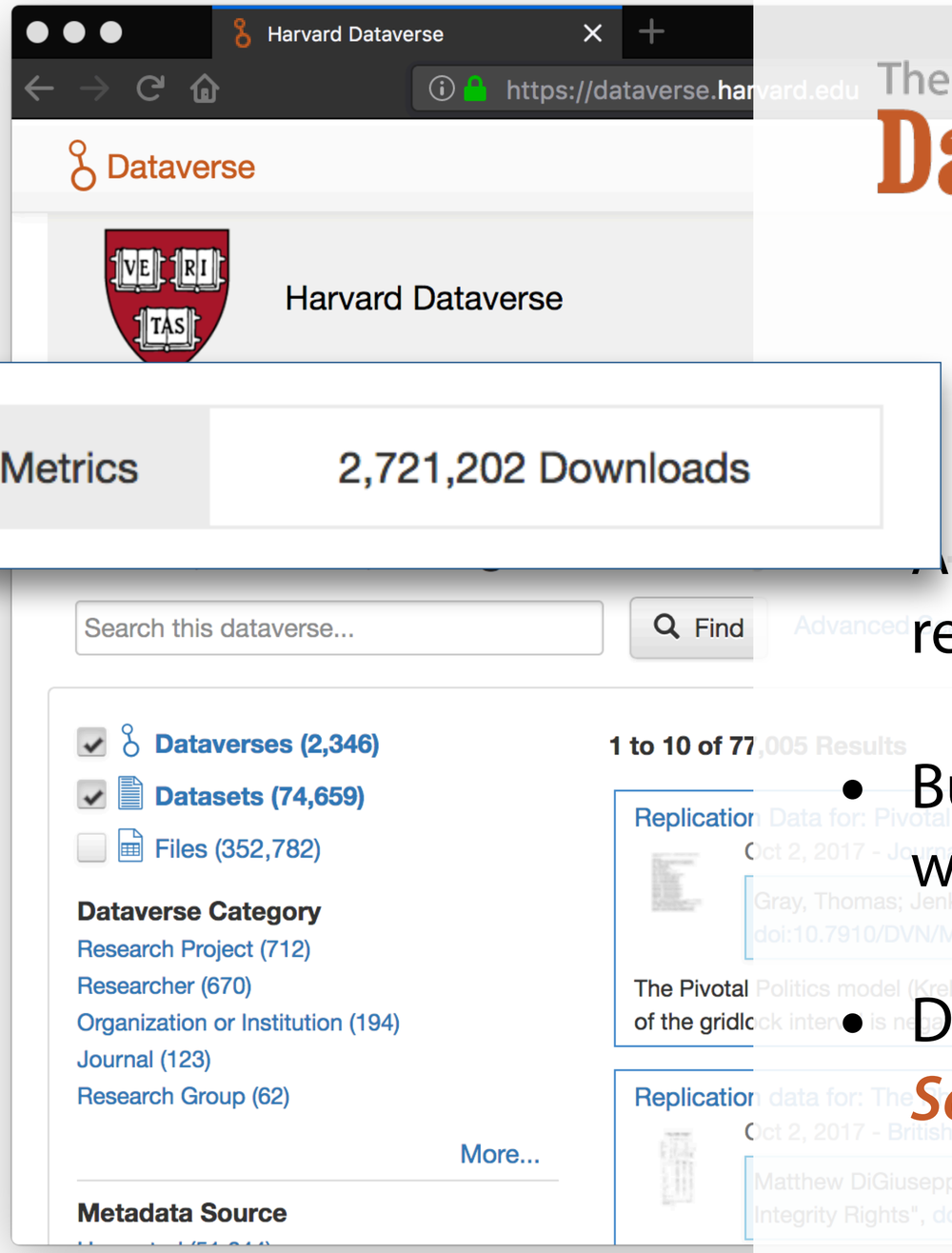
Oct 2, 2017 - British Journal of Political Science Dataverse

Matthew DiGiuseppe, 2016, "Replication data for: The Physical Consequences of Fiscal Flexibility: Sovereign Credit and Physical Integrity Rights", doi:10.7910/DVN/29544, Harvard Dataverse, V2, UNF:6:aBVN9cs4uamL7jQOuKARdw==



The Dataverse Project

- An open-source platform to publish, cite, and archive research data
- Built to support multiple types of data, users, and workflows
- Developed at ***Harvard's Institute for Quantitative Social Science*** (IQSS) since 2006



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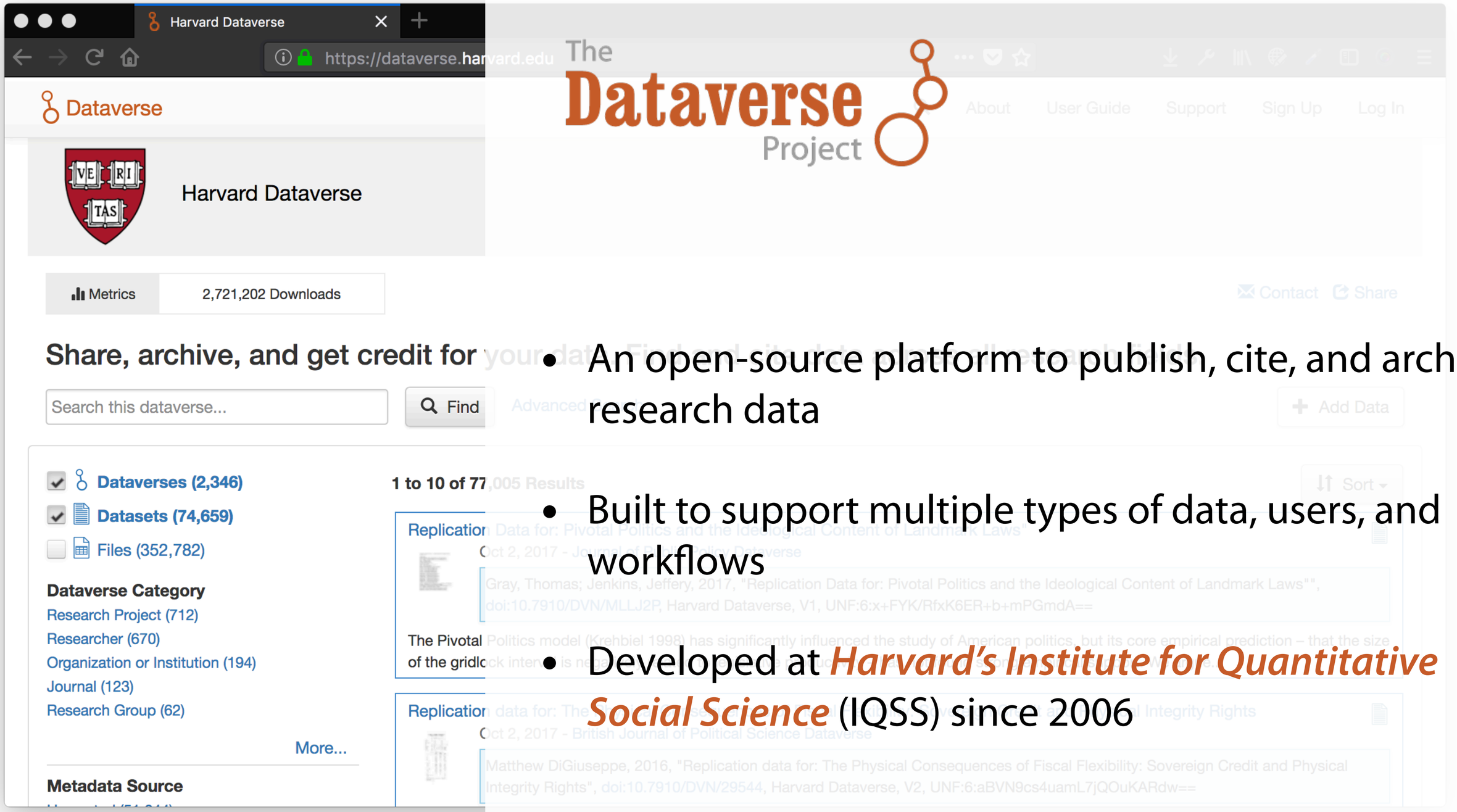

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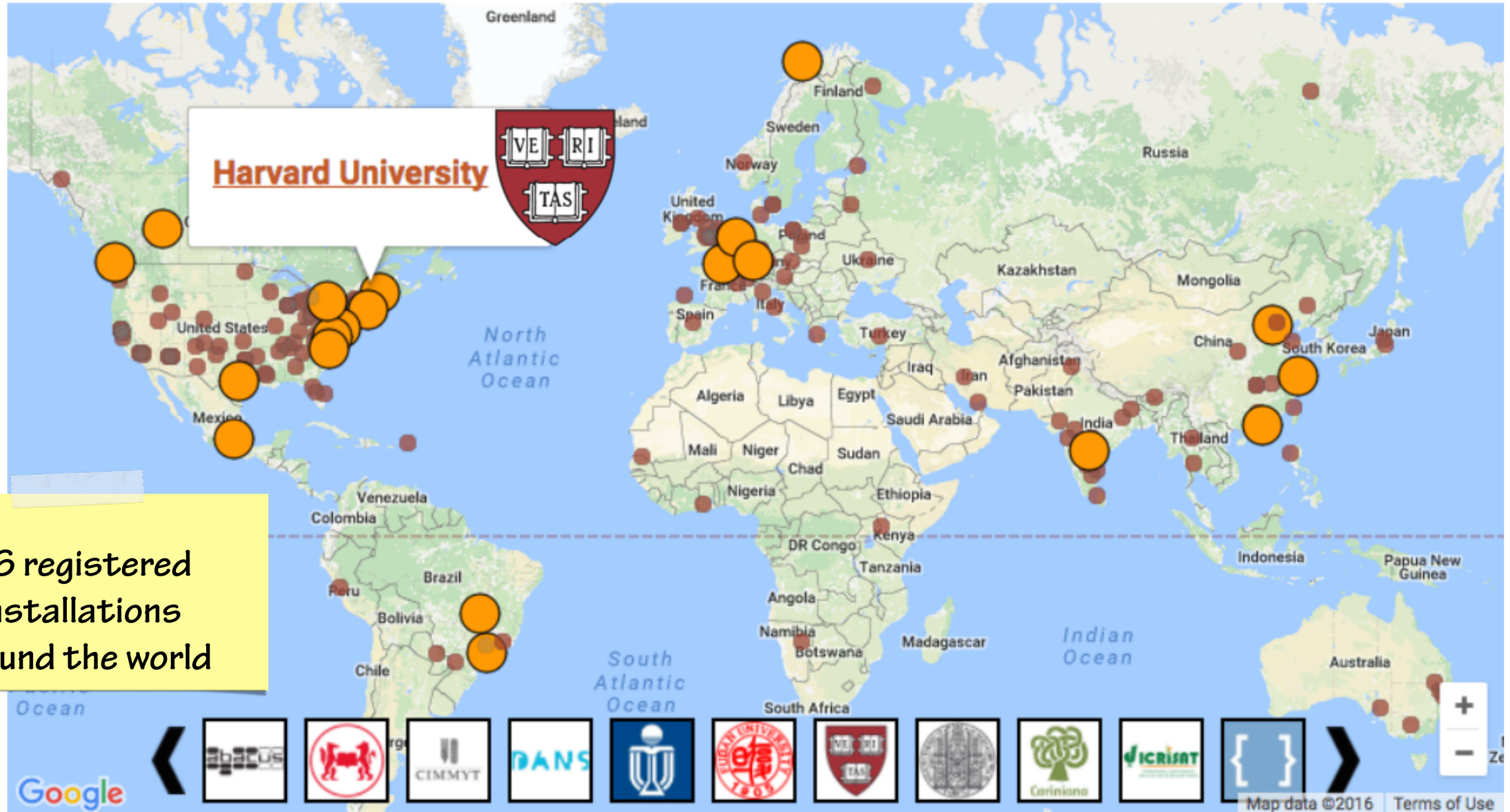
Dataverse Core Features

Dataverse Core Features

- Persistent IDs / URLs
- Automatically Generated Citations with attribution
- Domain-specific Metadata
- Data and metadata Versioning
- File Storage:
  - local
  - OpenStack
  - AWS S3
- Permissions
- Access Controls
- Terms of Use
- Publishing Workflows
- Private URLs
- Upload/Download via browser
- Upload/Download via rsync
- Upload/Download via Dropbox
- Multiple Sign In options
  - Native
  - Shibboleth
- OAuth (ORCID)
- Dataverses within Dataverses
- Branding
- Widgets
- APIs
  - SWORD
  - Native
- Harvesting (OAI-PMH)
  - Client
  - Server

Dataverse Community



26 registered installations around the world

Dataverse Community

- Hundreds of members of the Dataverse Community - developers, researchers, librarians, data scientists
  - Dataverse Google Group
  - Dataverse Community Calls
  - Dataverse Community Meeting
- 14,000+ Registered researchers on the Harvard Dataverse alone

Supporting the Dataverse Community

- **Installation-based needs**
  - Branding and customizations
  - Language support
- **Subject-based needs**
  - See next slides

Subject-based Needs

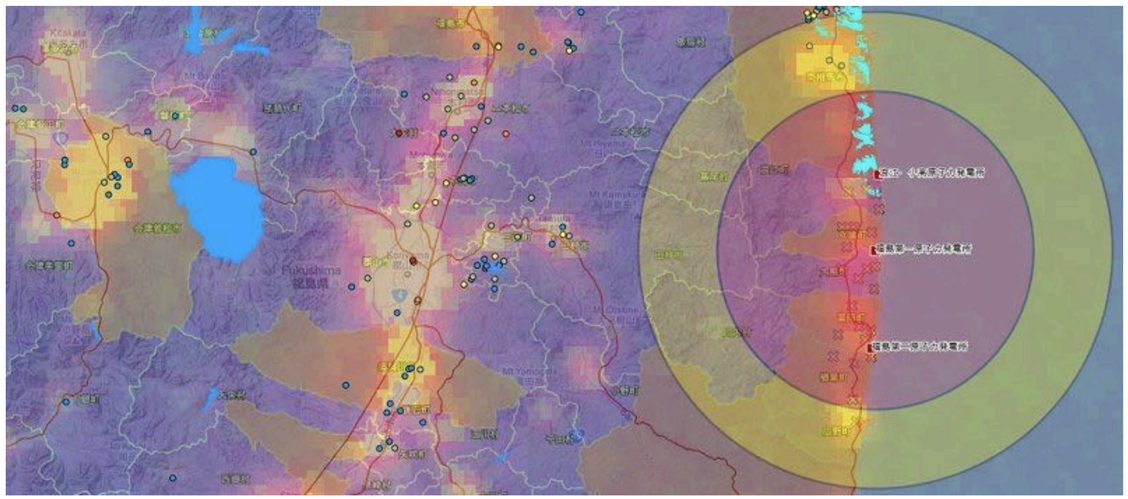
Quantitative Social Science

WorldMap
HARVARD UNIVERSITY

- Original use case
- Tabular Data / TwoRavens
- WorldMap

Zelig

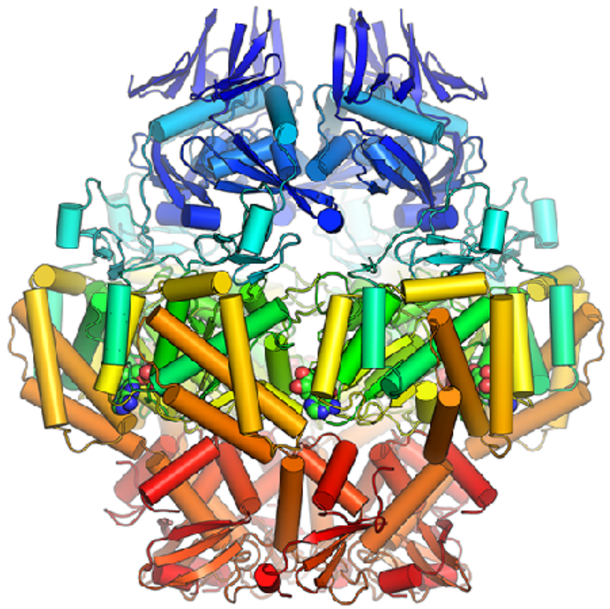
TwoRavens

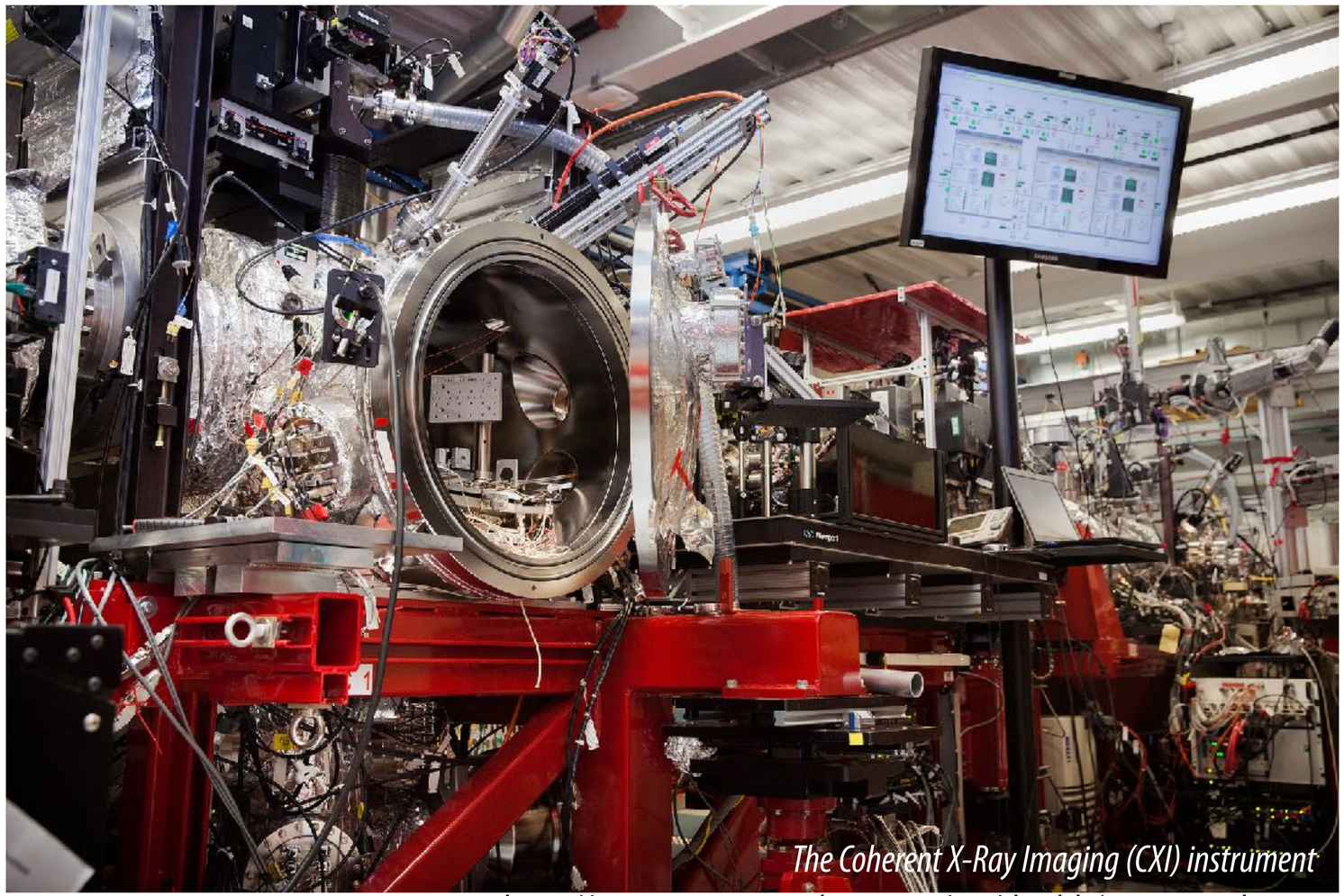


Subject-based Needs

Structural Biology

- Large data uploads
- Visualization support



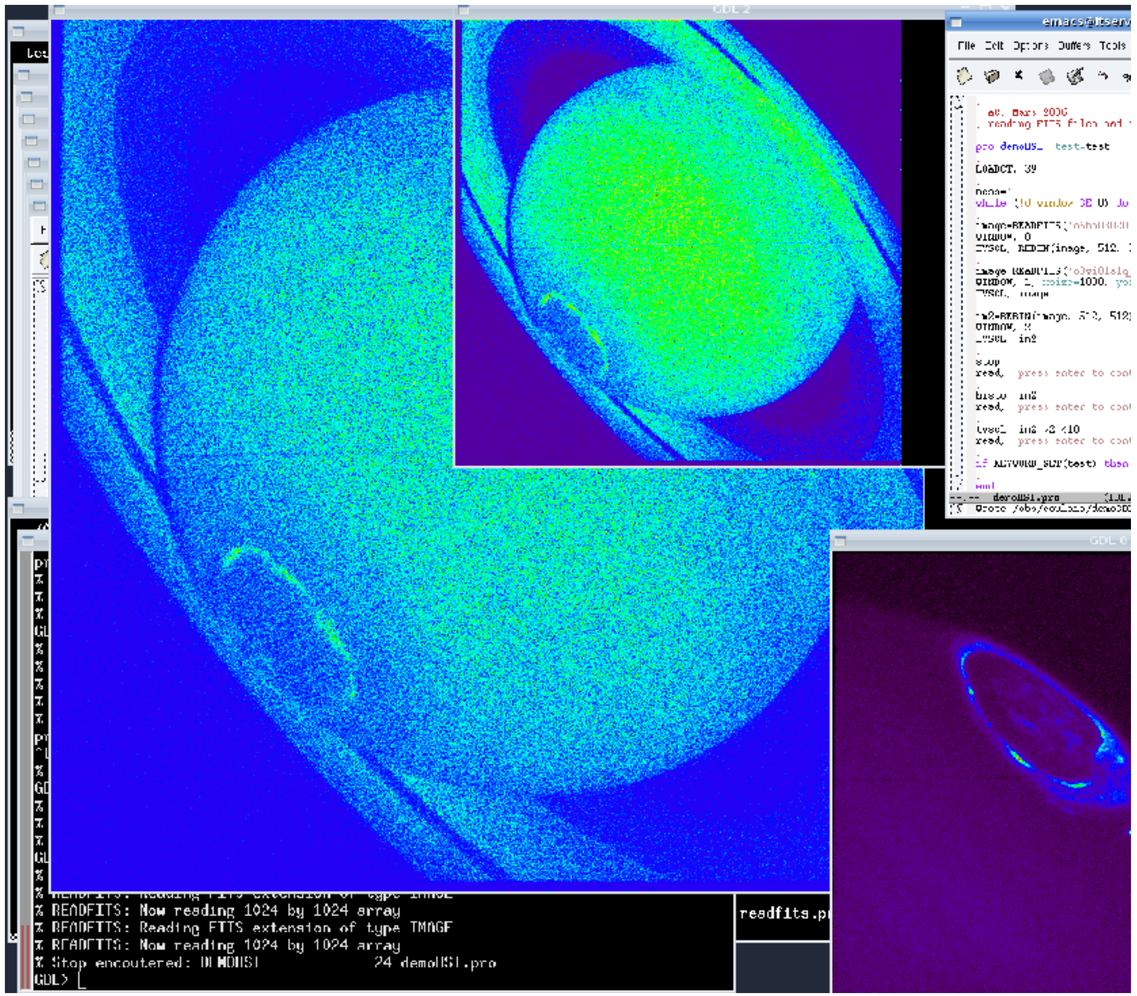


The Coherent X-Ray Imaging (CXI) instrument

https://sciencesprings.wordpress.com/tag/slac-lcls/#jp-carousel-39067

Subject-based Needs

Other Fields



- Astronomy: FITS format
- Expanding file format support
- Redhat system performance data

(Some) Collaborations

- **SBGrid Data** Large Data and Support

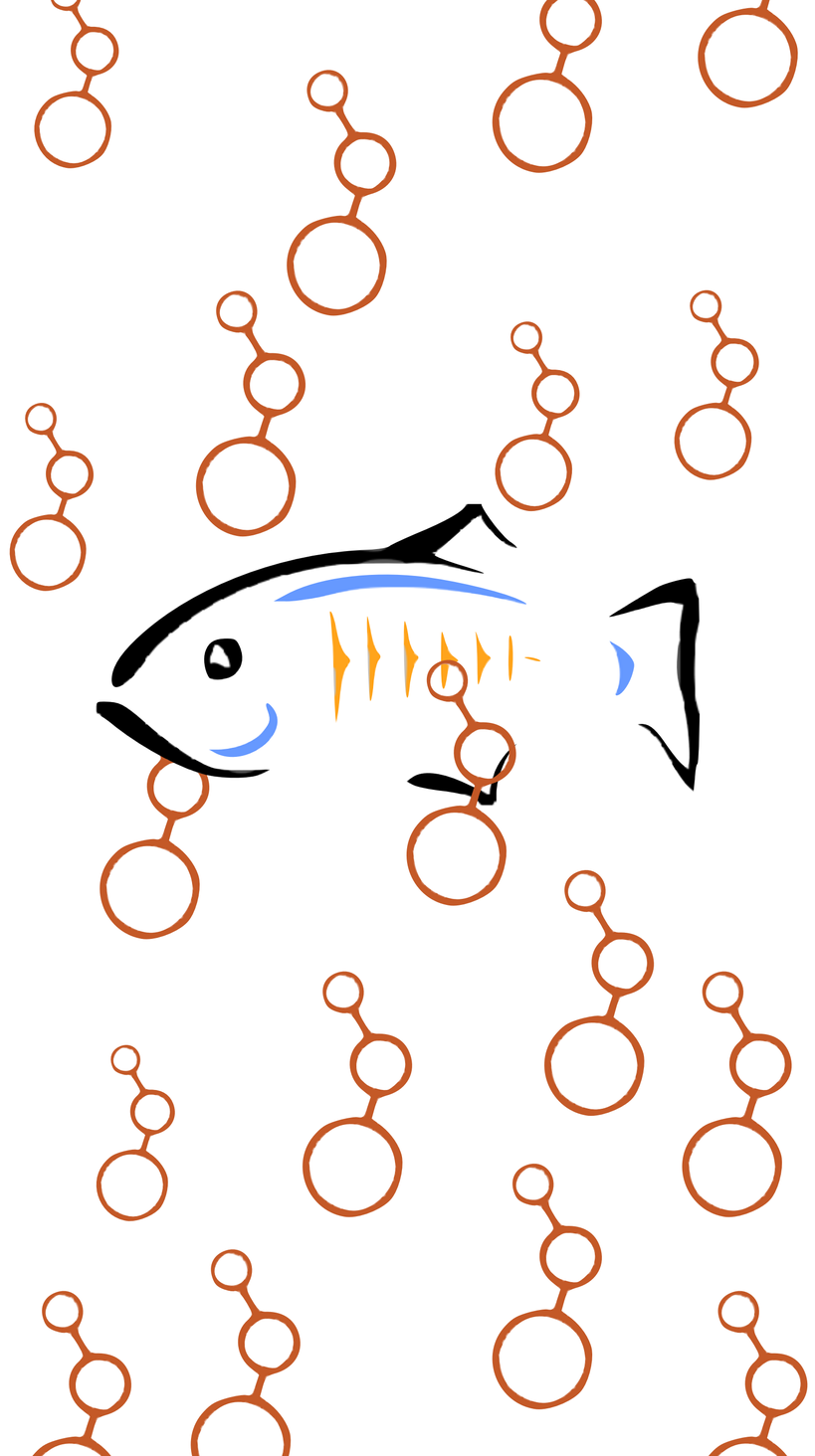
- **Massachusetts Open Cloud** Big Data Storage and Compute Access (OpenStack)

- **DANS/CIMMYT** Handles Support

- **ResearchSpace** API Java Client Library
- **W3C PROV** Provenance (soon)

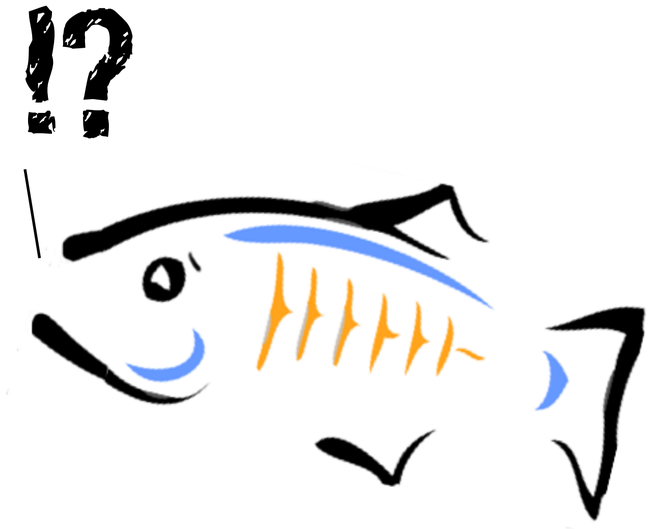
Technology

- Glassfish Server 4.1
- Java SE8
- Java EE7
  - Presentation: JSF (PrimeFaces), RESTful AP
  - Business: EJB, Transactions, Asynchronous, Timers, Adapted Command Pattern
  - Persistence: JPA (Entities), Bean Validation
- Storage: Postgres, Solr, File System / Swift / S3



Dataverse Codebase

```
App:    100,173 SLoC
Test:    16,081 SLoC
Total: 116,254 SLoC
generated using David A. Wheeler's 'SLOCCount'.
```



⚠️ Most functionality implemented in main codebase

HELP

- Goal:
  Offload Work from Core Team to Willing Community Members.

  - Lower bar needed to support community involvement

  - Facilitate Installation Customization

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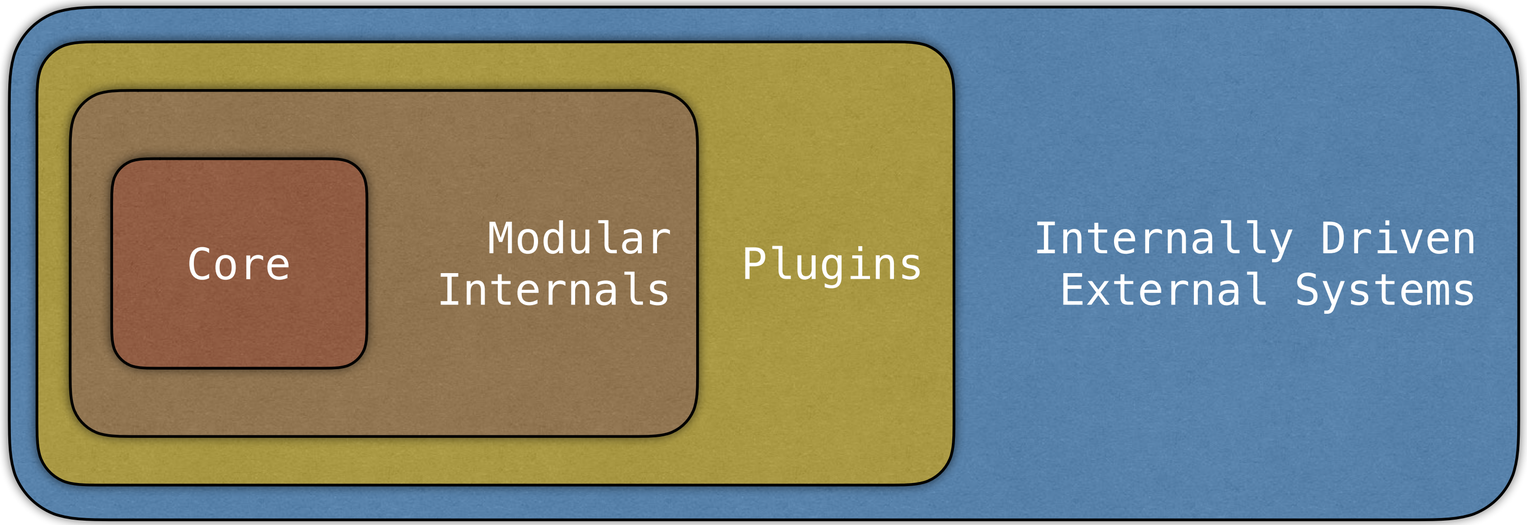
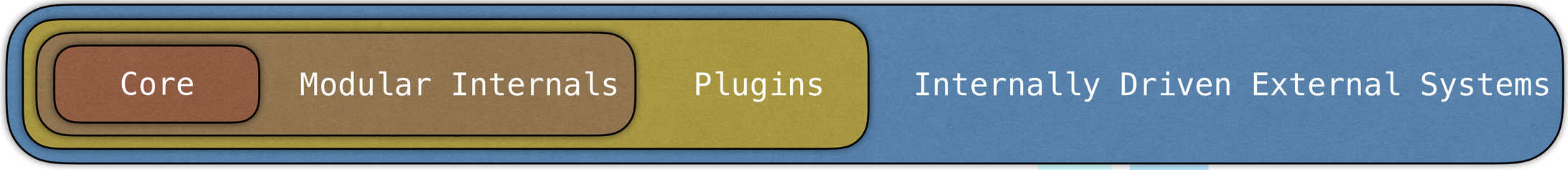
WE NEED MODULARITY.

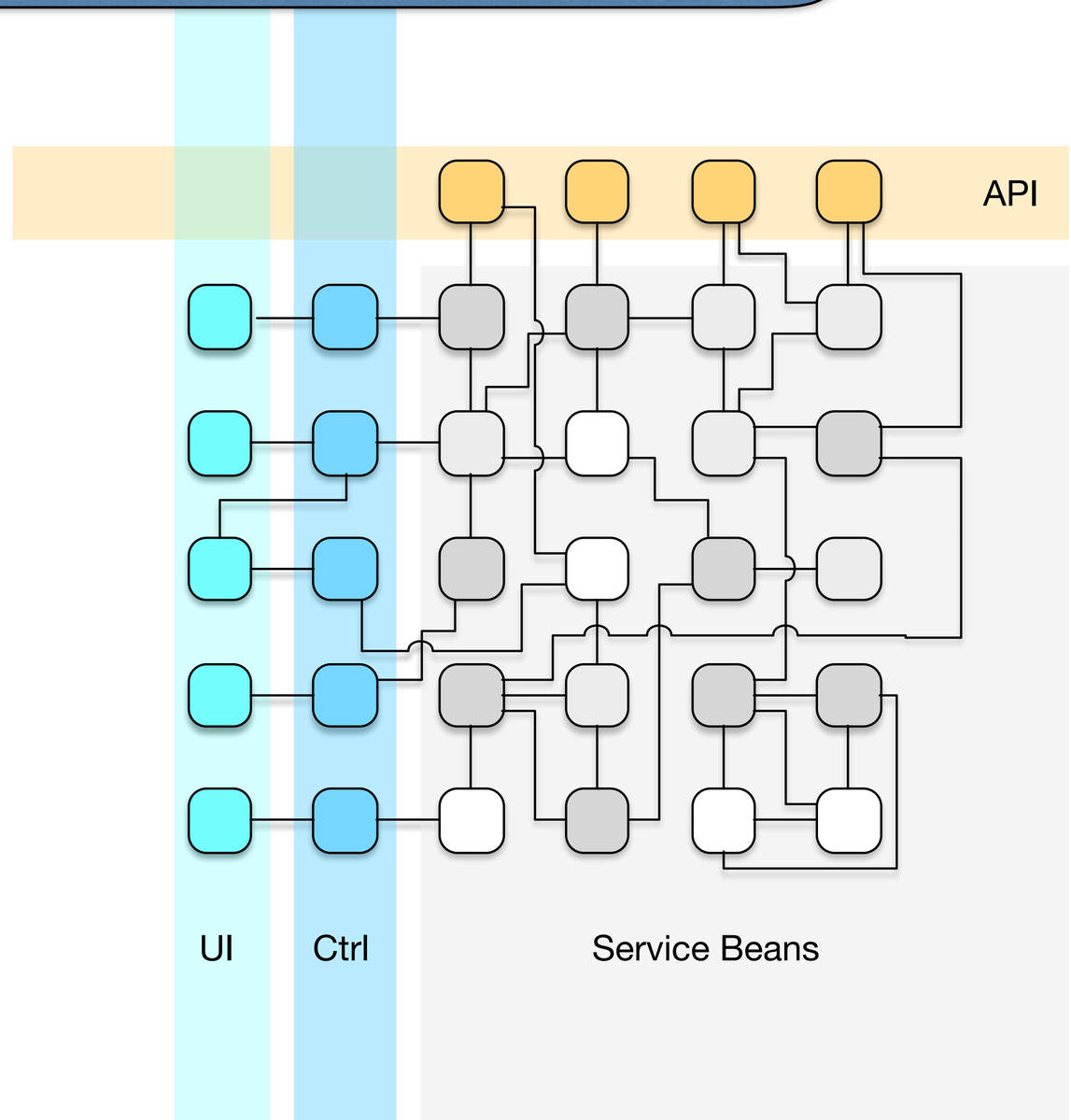
Modularity Levels

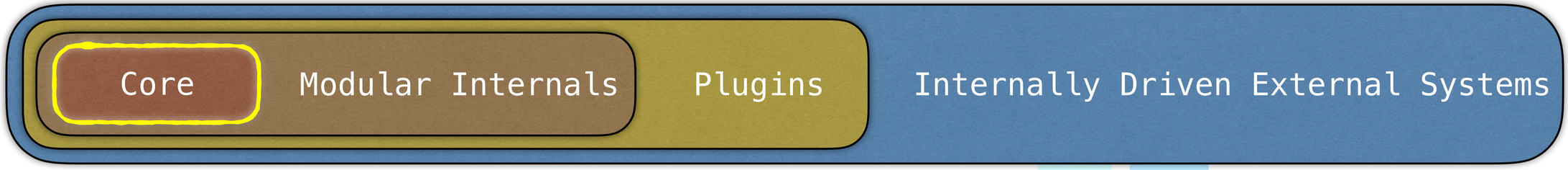




Core

- Layered Code
- Lots of inter-related parts, high-connectivity between various beans.
- Not really modular





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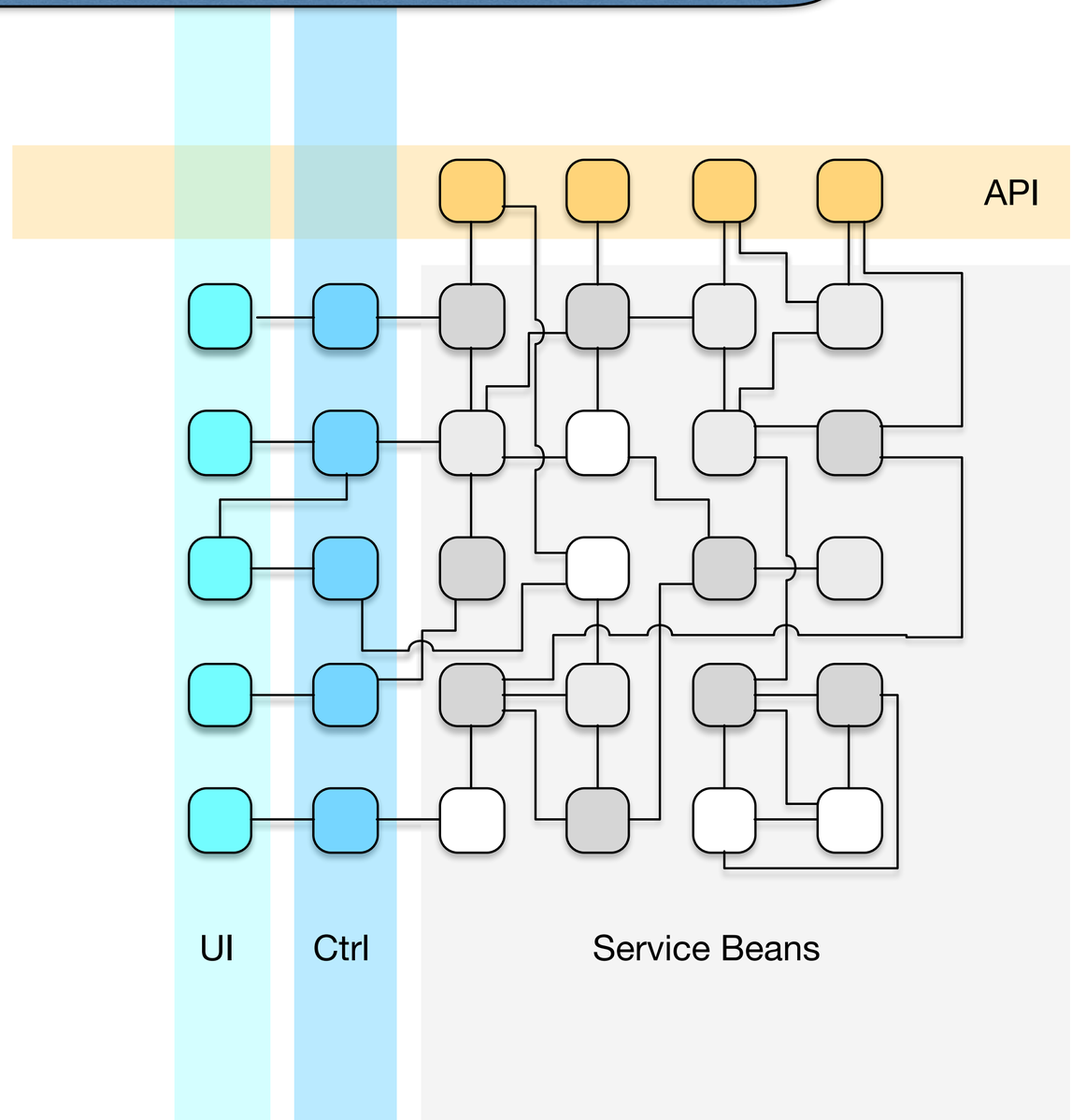

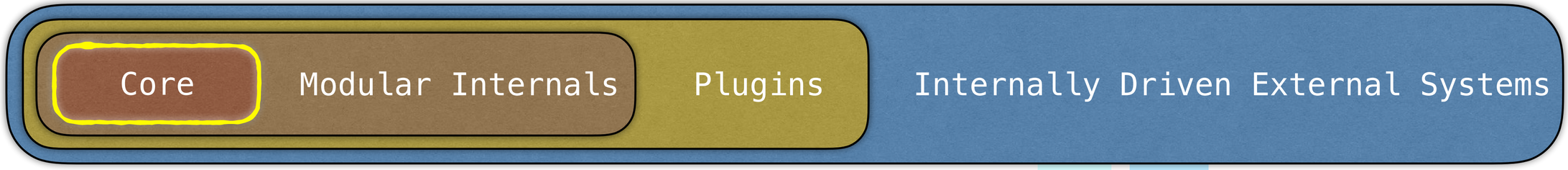

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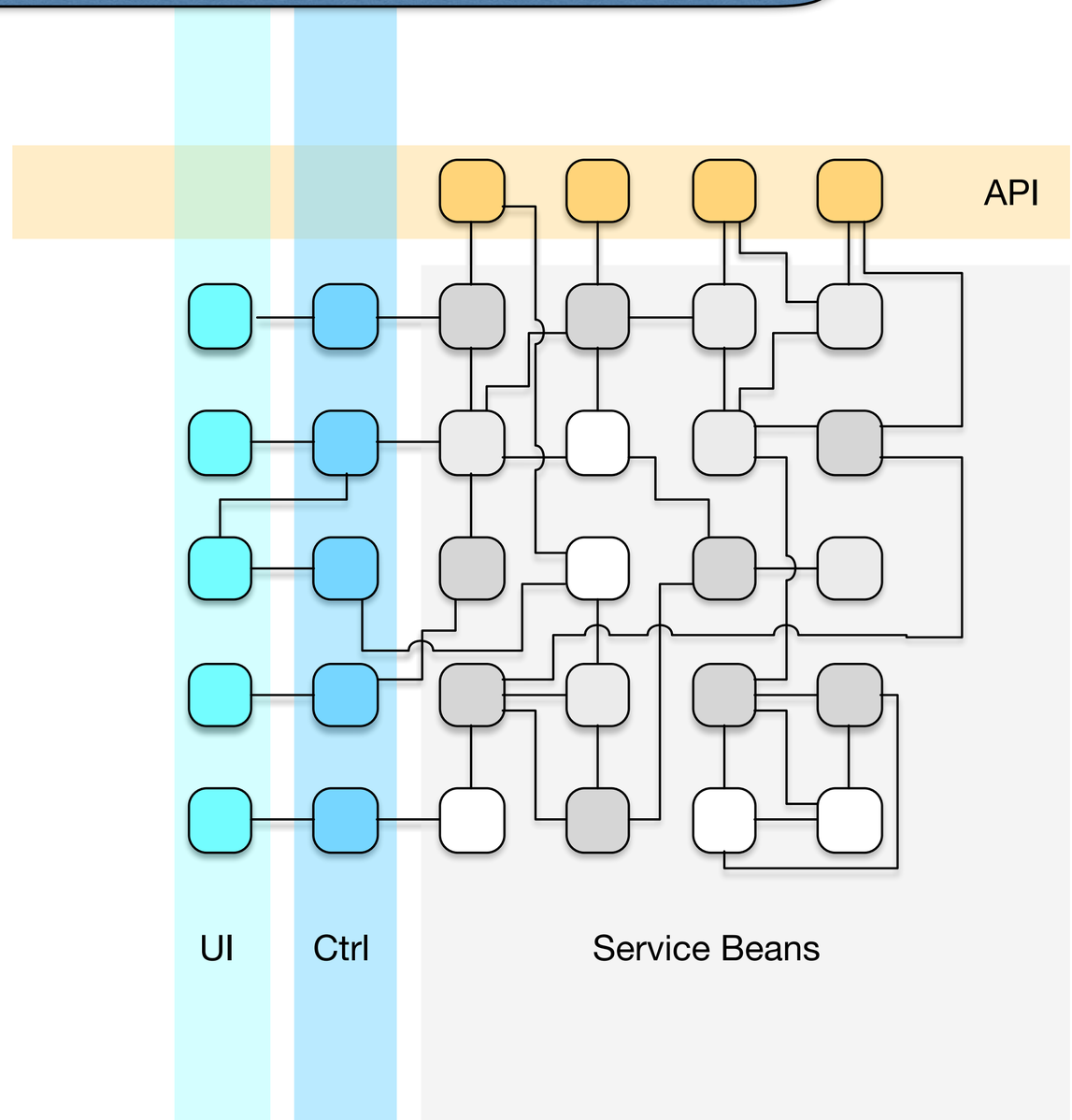
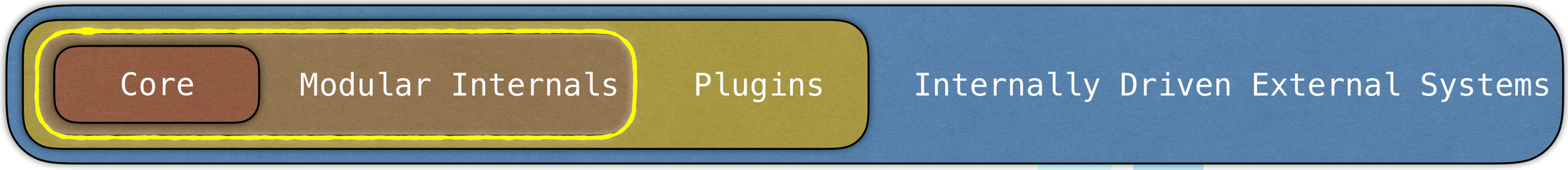
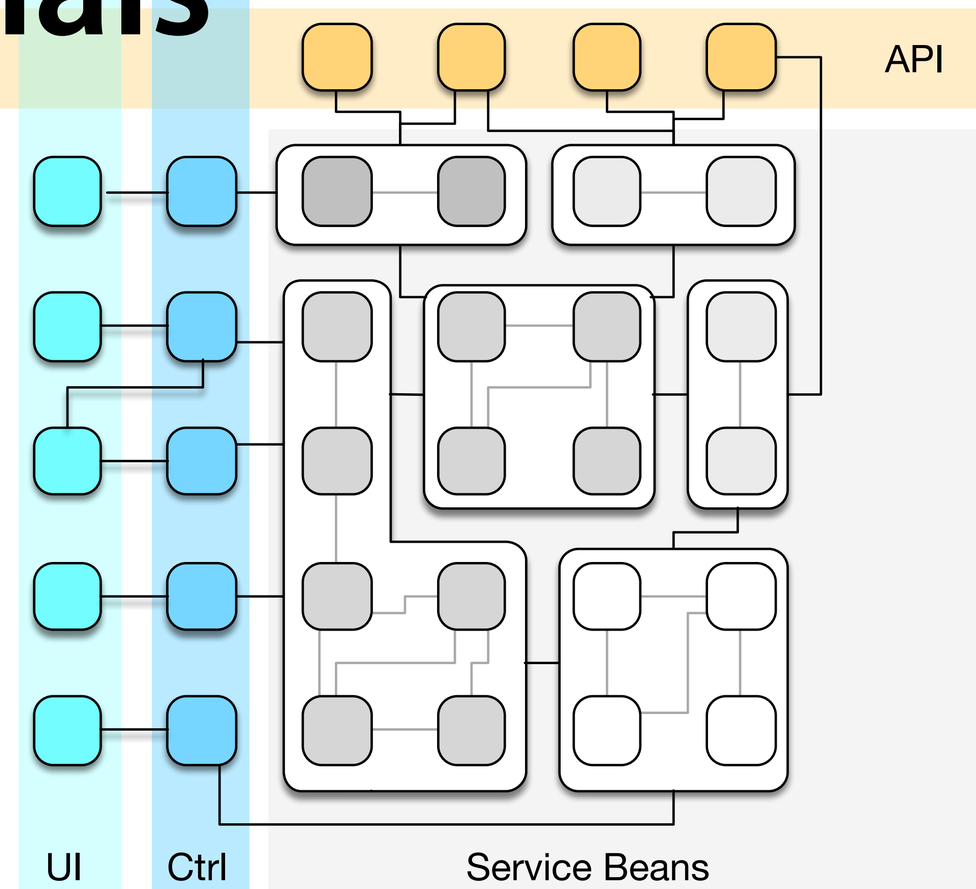
✘ Extension via fork-and-forget





Modular Internals

- Functionalities are implemented in *cohesive modules* with clear interface to the rest of the code
- Even though same code base, modules *don't get to make assumptions*
- Multiple patterns for this
- Jigsaw Helps



The Service Provider Interface (SPI)

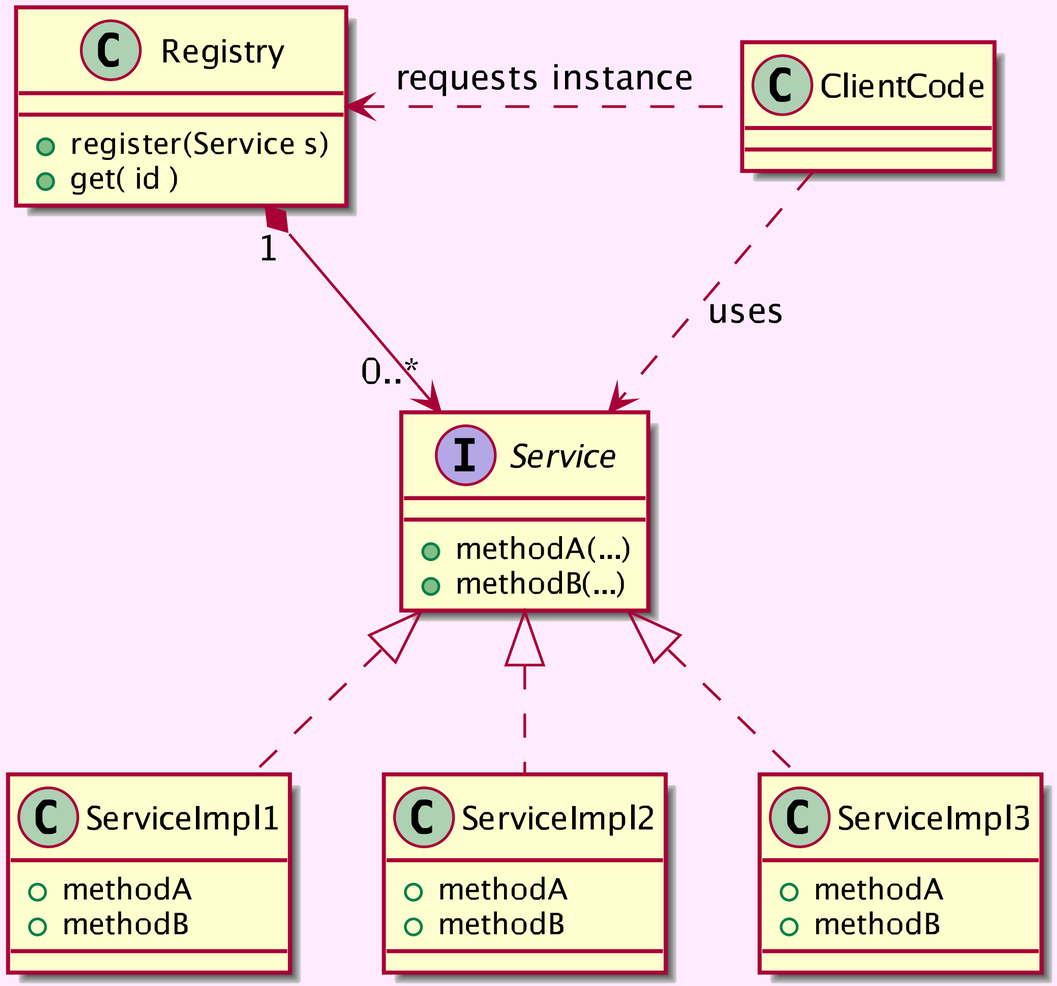


Diagram created using PlantUML

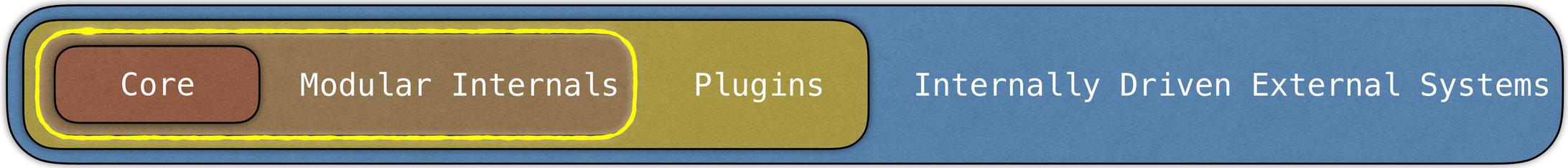
SPIs in Dataverse 4.x

```java
@PostConstruct
public void startup() {

    // First, set up the factories
    try {
        registerProviderFactory( new BuiltinAuthenticationProviderFactory(builtinUserServiceBean, passwordValidatorService) );
        registerProviderFactory( new ShibAuthenticationProviderFactory() );
        registerProviderFactory( new OAuth2AuthenticationProviderFactory() );

    } catch (AuthorizationSetupException ex) {
        logger.log(Level.SEVERE, "Exception setting up the authentication provider factories: " + ex.getMessage(), ex);
    }
```

❤️🧊 *actual production code*



Modular Internals

Codebase

- Size remains roughly the same

✔ Extension via pull-requests

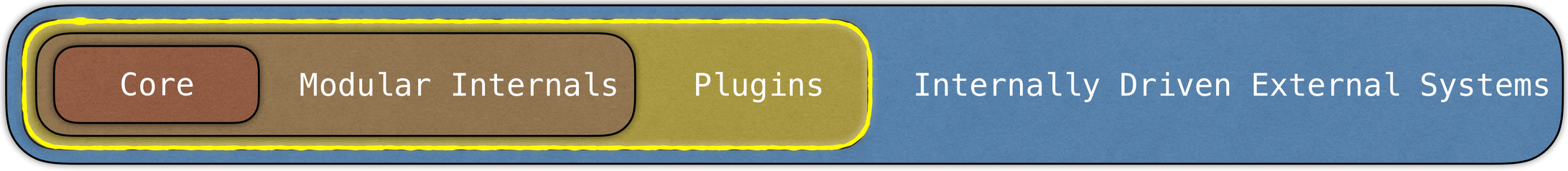
Headache

✔ Can **flip the ignorance switch** on module internals when not within a module

✔ Improves **code comprehension**

✔ **Less merge conflicts** between team members / collaborators

✔ **Internal** change

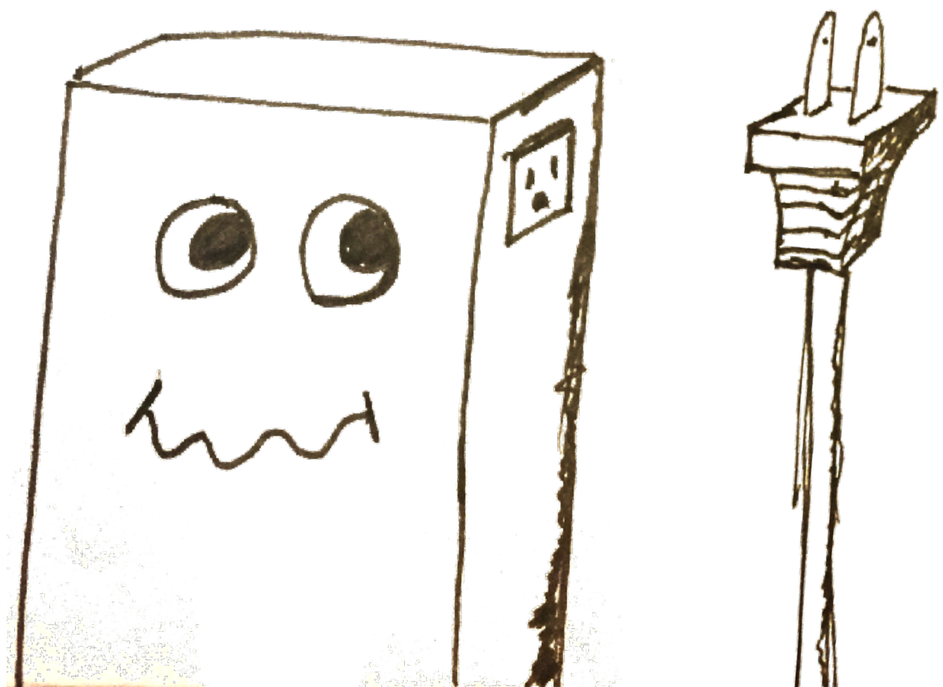


Plugins

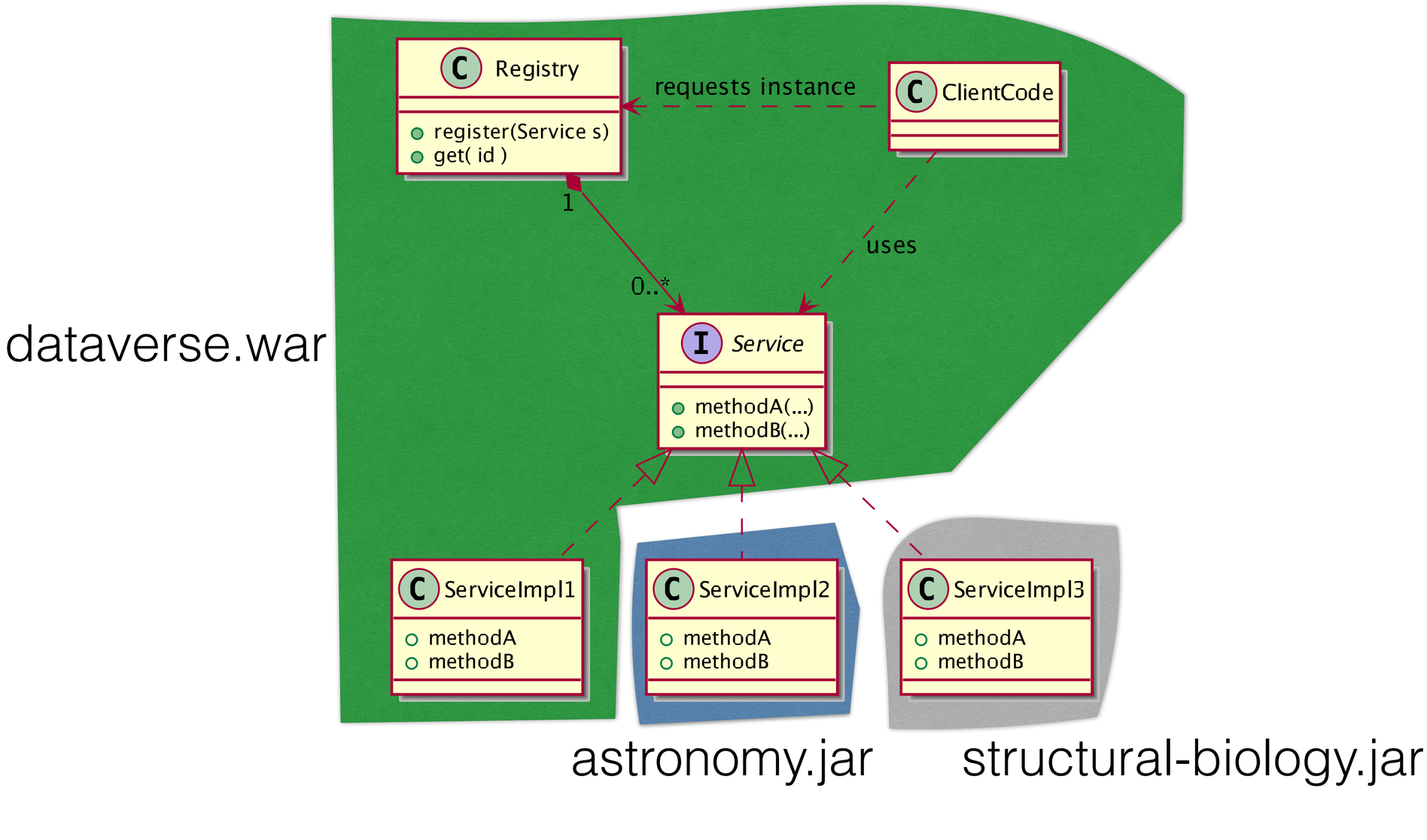
- Third parties implement SPIs, pack them in .jar files, and declare which services they provide
  Using META-INF/services or Project Jigsaw modules

- Core application team adds functionality to dynamically load implementation from .jar files

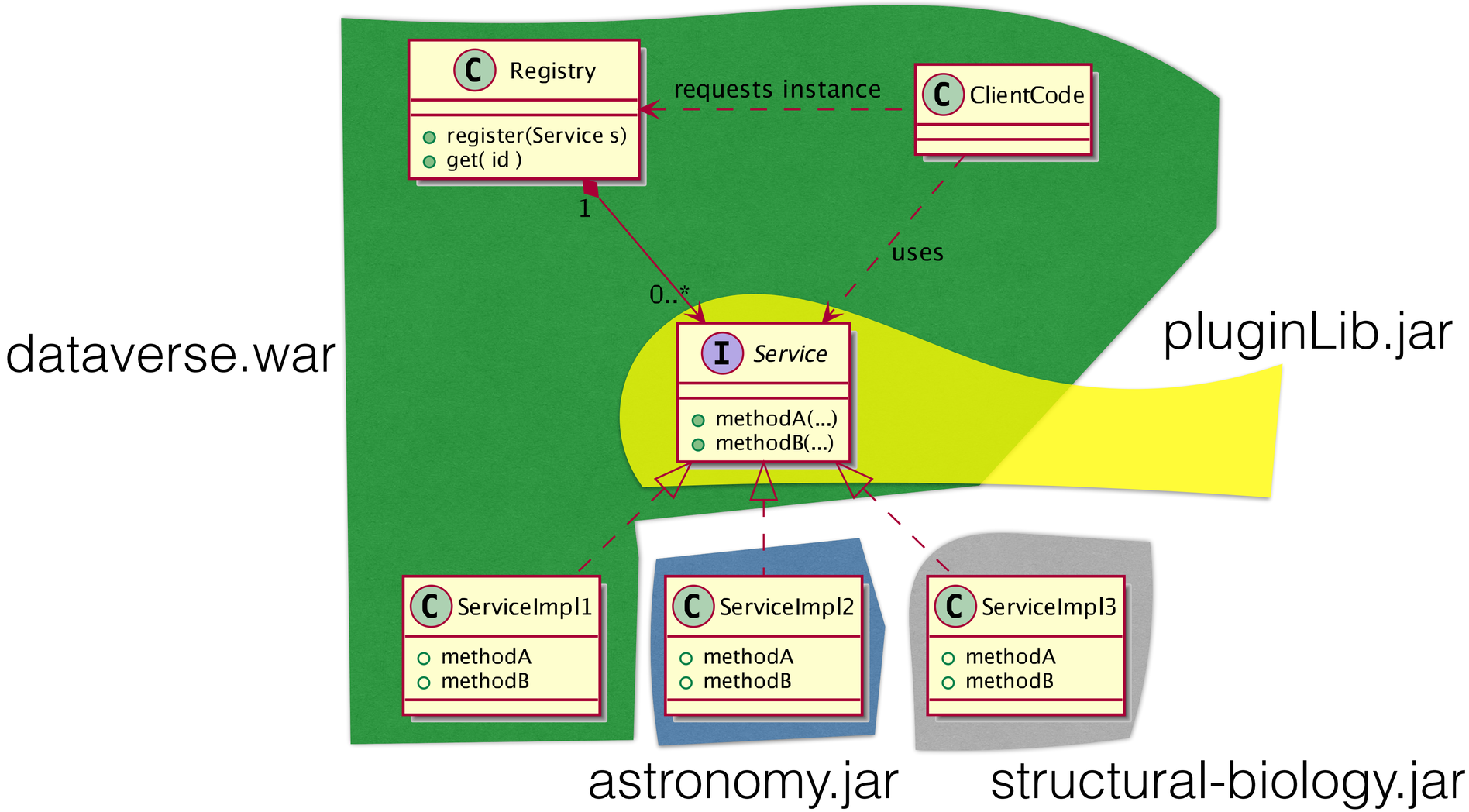
- Admins add .jar files to installations' classpath



SPI + PlugIns


Registry
register(Service s)
get(id)
requests instance
ClientCode
1
0..*
uses
Service
methodA(...)
methodB(...)
ServiceImpl1
methodA
methodB
ServiceImpl2
methodA
methodB
ServiceImpl3
methodA
methodB
dataverse.war
astronomy.jar
structural-biology.jar

SPI + PlugIns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methodB
ServiceImpl3
methodA
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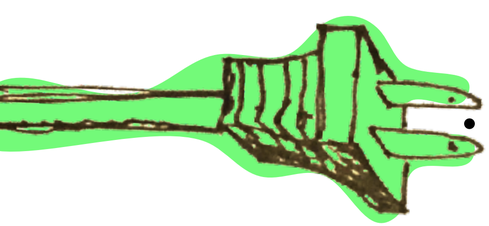
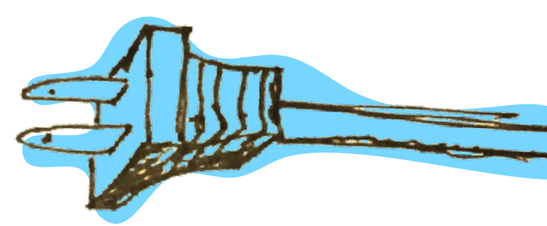
pluginLib.jar
astronomy.jar
structural-biology.jar

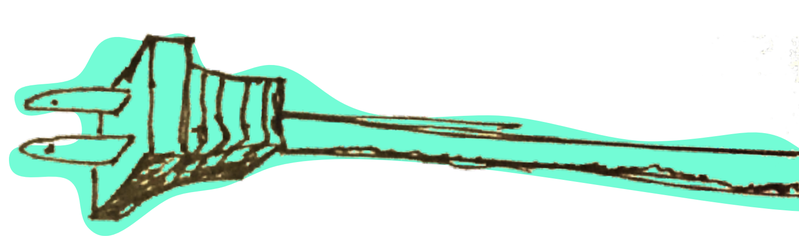
Writing Plugins



- Put classes available to plugins on a new .jar



  - Alas, that's another public API you need to maintain

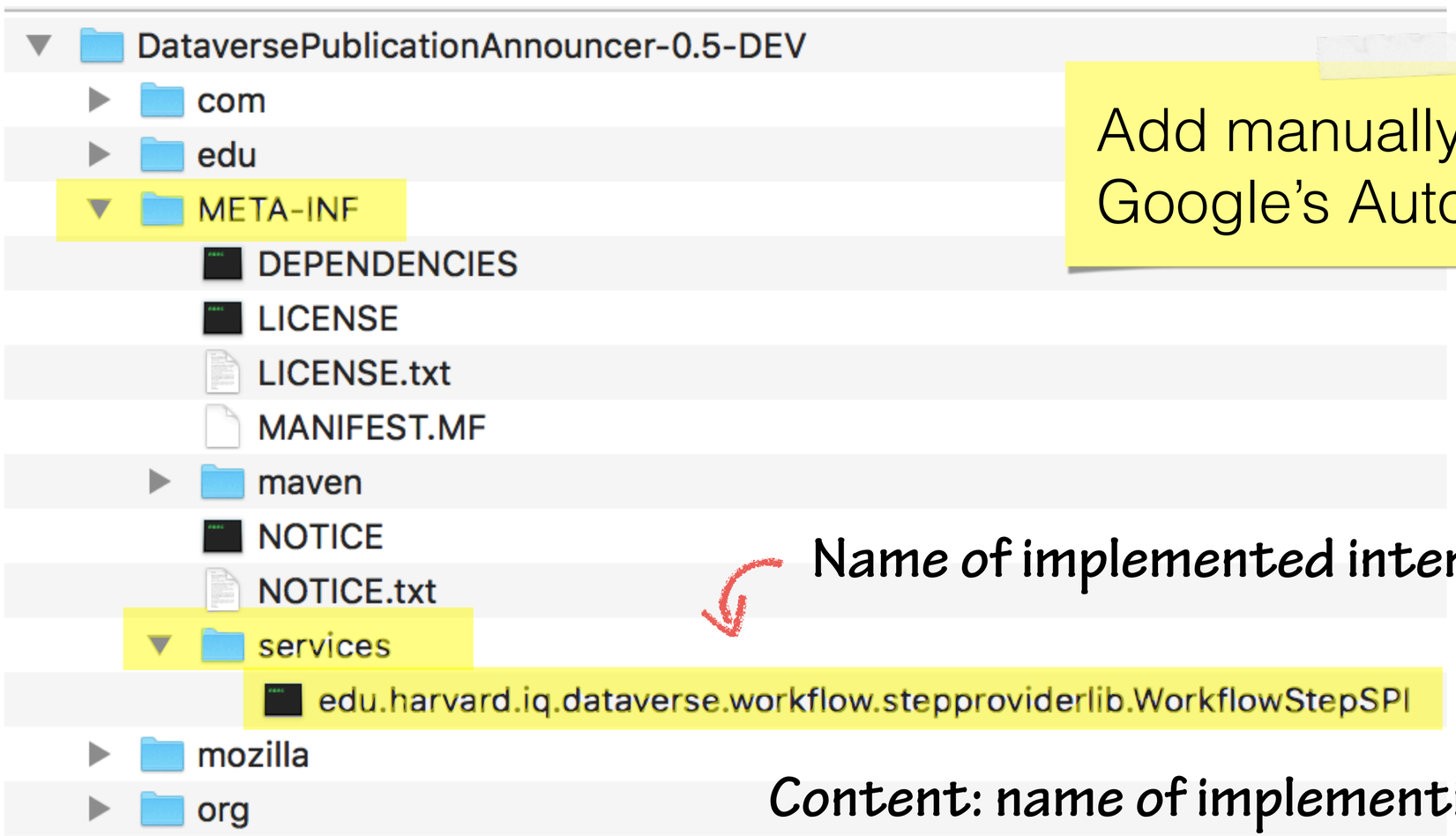


    - *Careful what you expose*

- Third parties implement providers in another .jar, and declare provided services

- Monolith loads plugins upon startup

Plugin .jar File Layout



Loading Plugins

1) Place the plugin .jar file in the lib folder inside the domain folder

2) Load like so:

```
public WorkflowServiceBean() {
    providers.put(":internal", new InternalWorkflowStepSP());

    logger.log(Level.INFO, "Searching for workflow step providers...");
    ServiceLoader<WorkflowStepSPI> loader = ServiceLoader.load(WorkflowStepSPI.class);
    try {
        for ( WorkflowStepSPI wss : loader ) {
            logger.log(Level.INFO, "Found WorkflowStepProvider: {0}", wss.getClass().getCanonicalName());
            providers.put( wss.getClass().getCanonicalName(), wss );
        }
        logger.log(Level.INFO, "Searching for Workflow Step Providers done.");
    } catch (NoClassDefFoundError ncdfe) {
        logger.log(Level.WARNING, "Class not found: " + ncdfe.getMessage(), ncdfe);
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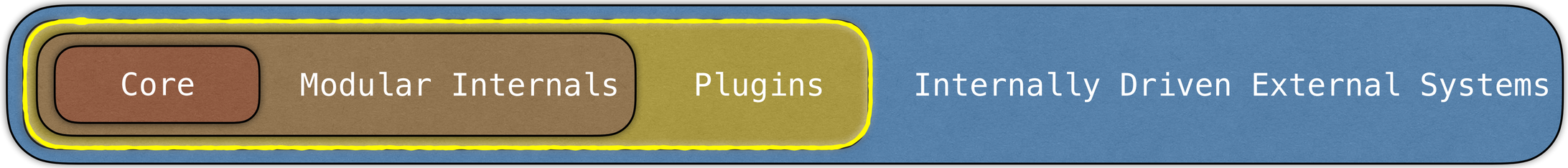
    try {
        for ( WorkflowStepSPI wss : loader ) {
            logger.log(Level.INFO, "Found WorkflowStepProvider: {0}", wss.getClass().getCanonicalName());
            providers.put( wss.getClass().getCanonicalName(), wss );
        }
        logger.log(Level.INFO, "Searching for Workflow Step Providers done.");
    } catch (NoClassDefFoundError ncdfe) {
        logger.log(Level.WARNING, "Class not found: " + ncdfe.getMessage(), ncdfe);
    } catch (ServiceConfigurationError serviceError) {
```

Caution:
Classpath Issues Ahead

- Java SE class loading is standardized and intuitive
- Java EE class loading - not so much
  - Plugin dependencies may need to be added with the plugin, even if the application already depends on them (container dependent!)



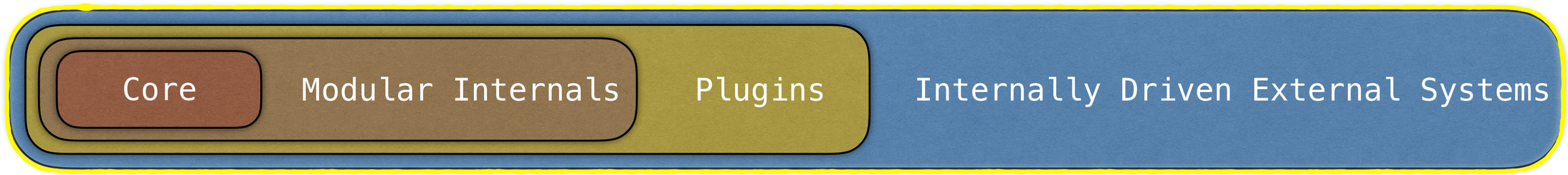
Plugins

Codebase

- ✔ Size can go down as functionality is moved out
- ✔ Extension via jar files

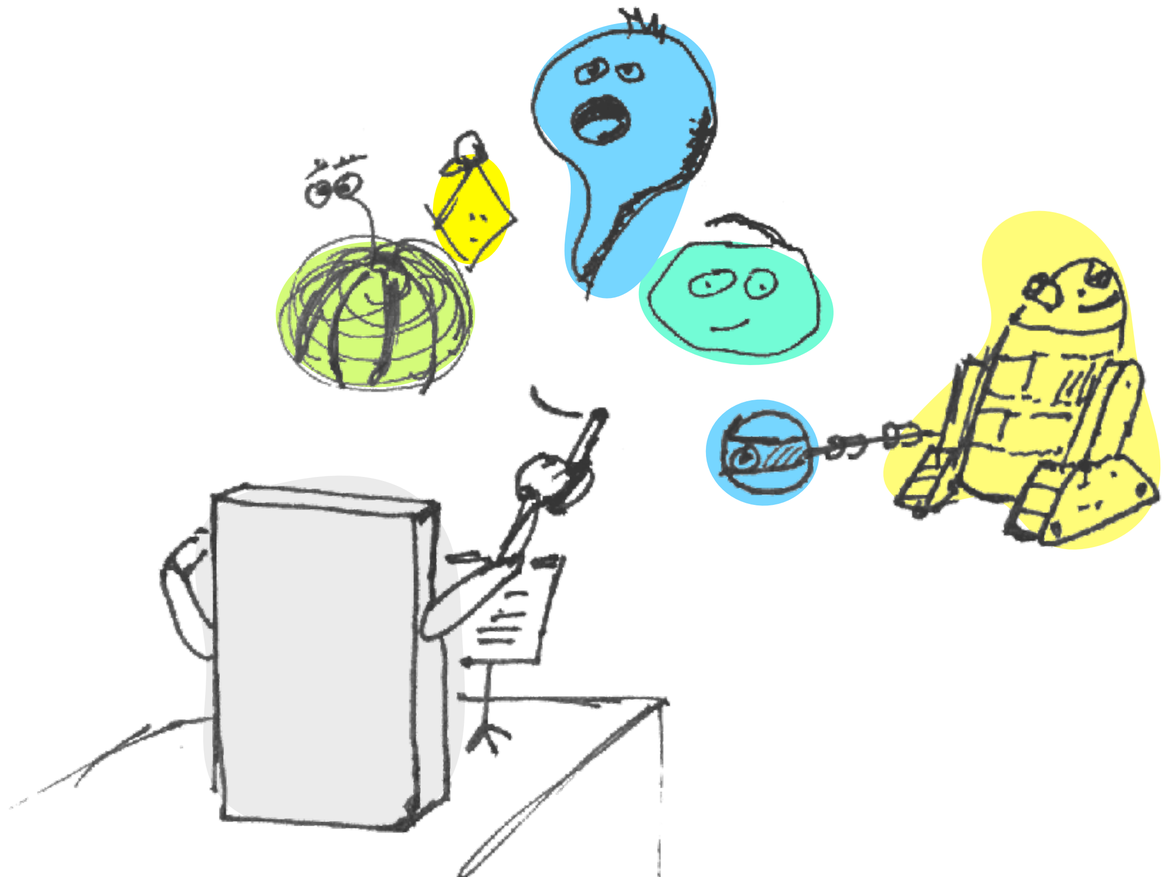
Headache

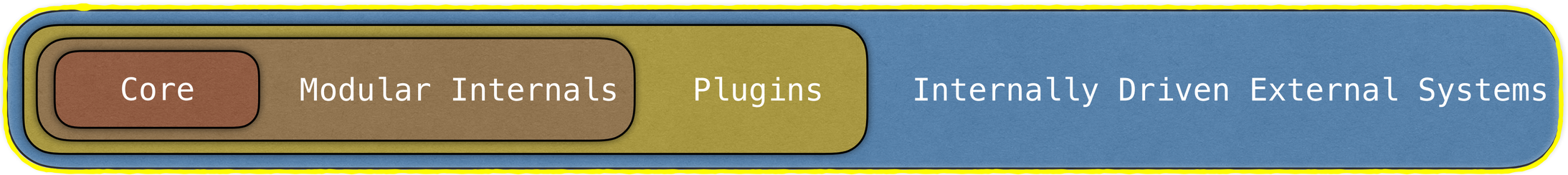
- ✔ Empowers the community to add functionality on its own
- ✘ A new public interface to maintain
- ✘ Security and stability may be an issue



Internally Driven External Systems (IDES)

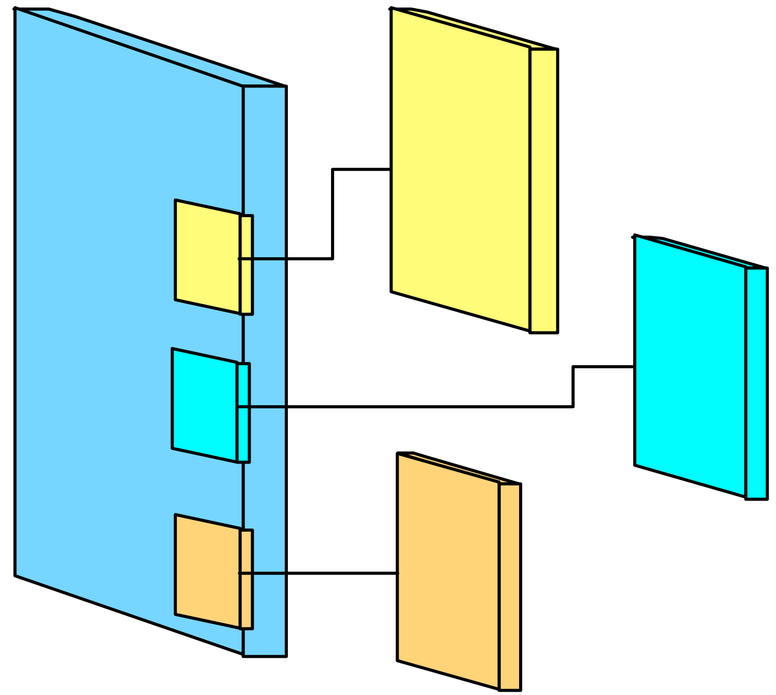
- Core application sends requests to external systems (and waits)
- External systems reports back
- ***Smaller monolith that orchestrates other systems***

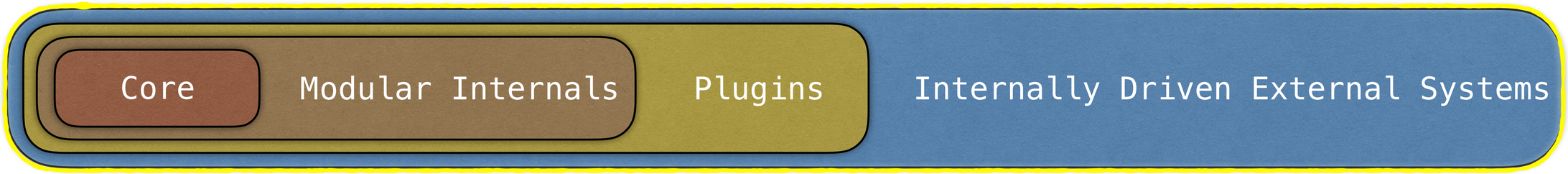




Remote-Aware IDES

- Monolith is aware of the external system, actually holding a specific piece of code for it
  - Essentially, a driver
- Not super modular, just broken into two.

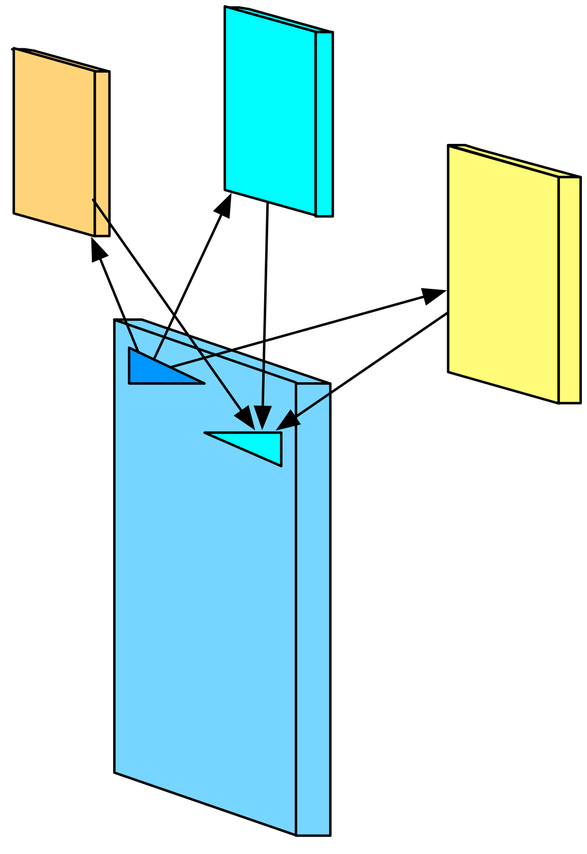


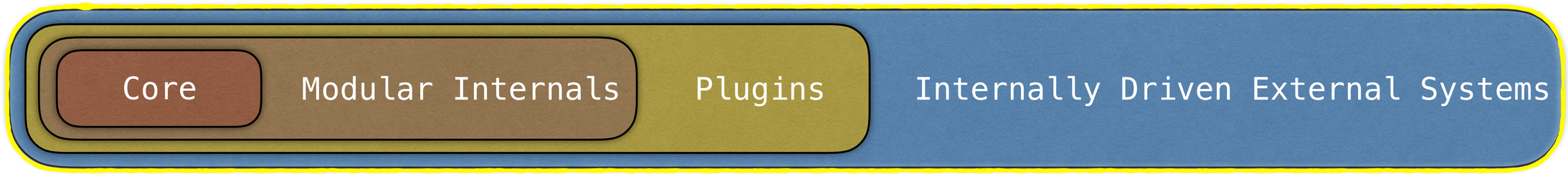


Standard Interface IDES

- Monolith provides a configurable way of sending messages and receiving responses

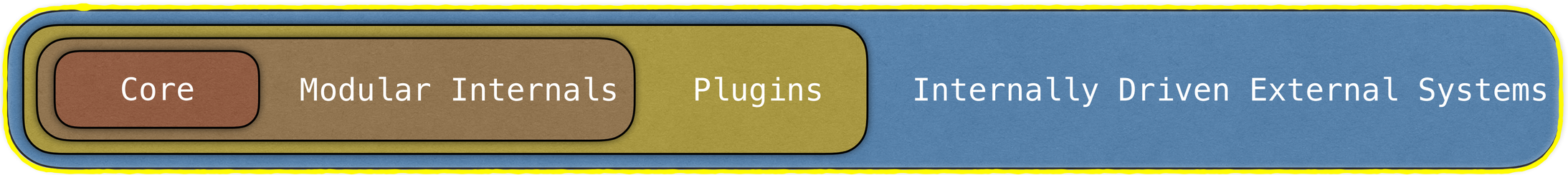
- Remote systems implement standard for listening and responding





Standard Interface IDES Example: **REST Client**

```
{
  "provider":":internal",
  "stepType":"http/sr",
  "parameters": {
      "url":"http://localhost:5050/dump/${invocationId}",
      "method":"POST",
      "contentType":"text/plain",
      "body":"START RELEASE ${dataset.id} as ${dataset.displayName}",
      "expectedResponse":"OK.*",
      "rollbackUrl":"http://localhost:5050/dump/${invocationId}",
      "rollbackMethod":"DELETE ${dataset.id}"
  }
}
```



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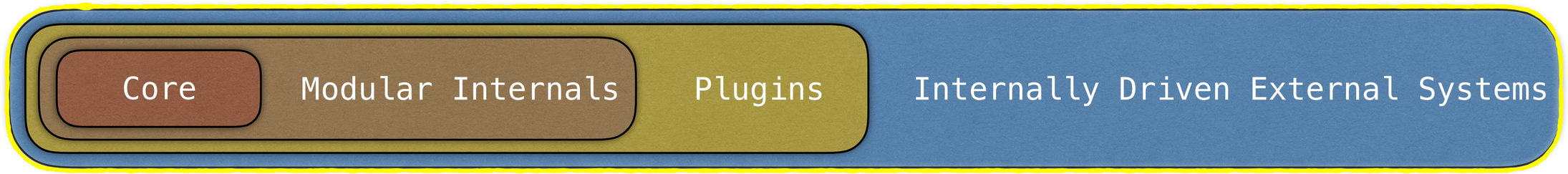
      "expectedResponse":"OK.*",
      "rollbackUrl":"http://localhost:5050/dump/${invocationId}",
      "rollbackMethod":"DELETE ${dataset.id}"
  }
}
```

Available variables are:

- `invocationId`
- `dataset.id`
- `dataset.identifier`
- `dataset.globalId`
- `dataset.displayName`
- `dataset.citation`
- `minorVersion`
- `majorVersion`
- `releaseStatus`



Standard Interface IDES

Codebase

- ✔ Size can go down as functionality is moved out
- ✔ Extension via configuration

Headache

- ✔ Empowers the community to add functionality on its own
- ✔ Core team not aware of remote systems at all

Case Study: ***Publication Workflows***

or

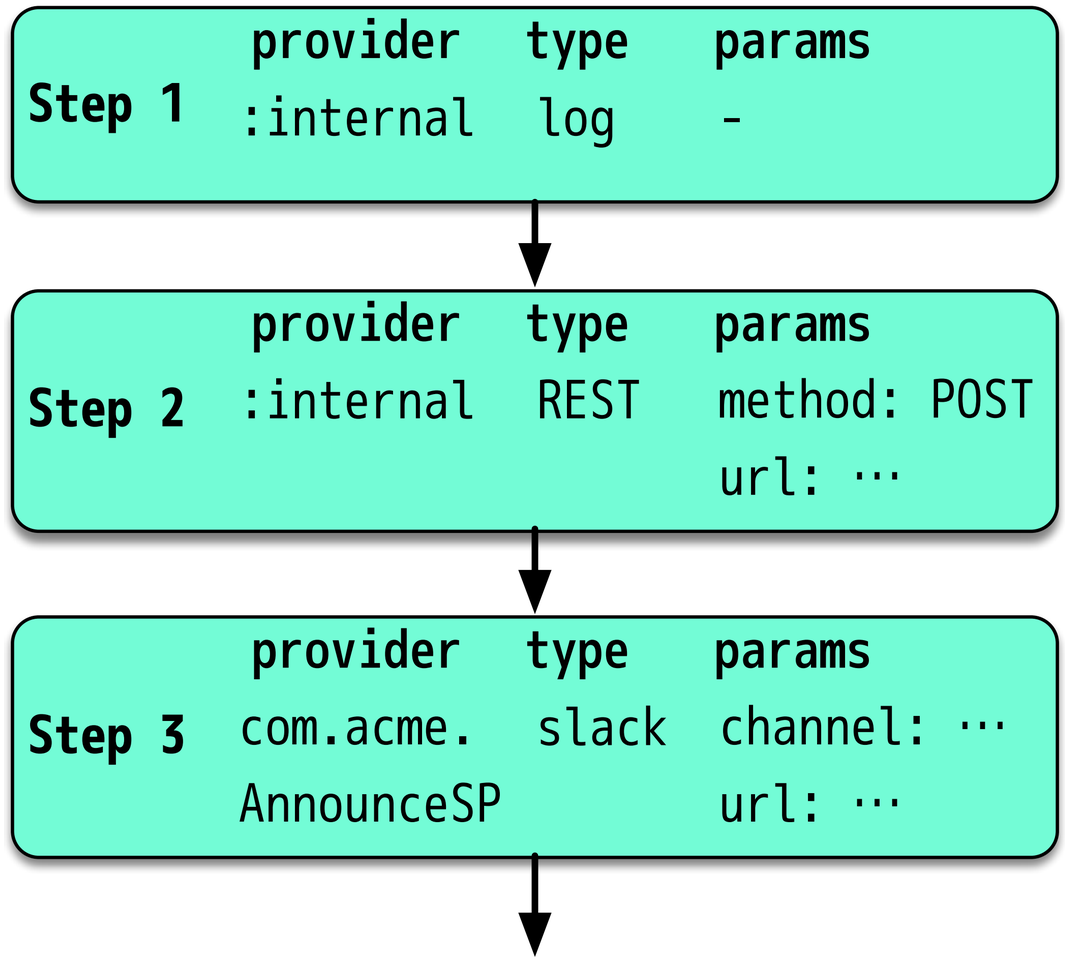
Mix everything and add users

Publication Workflows

- Releasing a dataset may require actions by external, 3rd party systems
- Different domains use different systems
- Actions may fail
- Actions may take an arbitrarily amount of time
  - e.g. human approval or transferring terabytes

Publication Workflows: Design

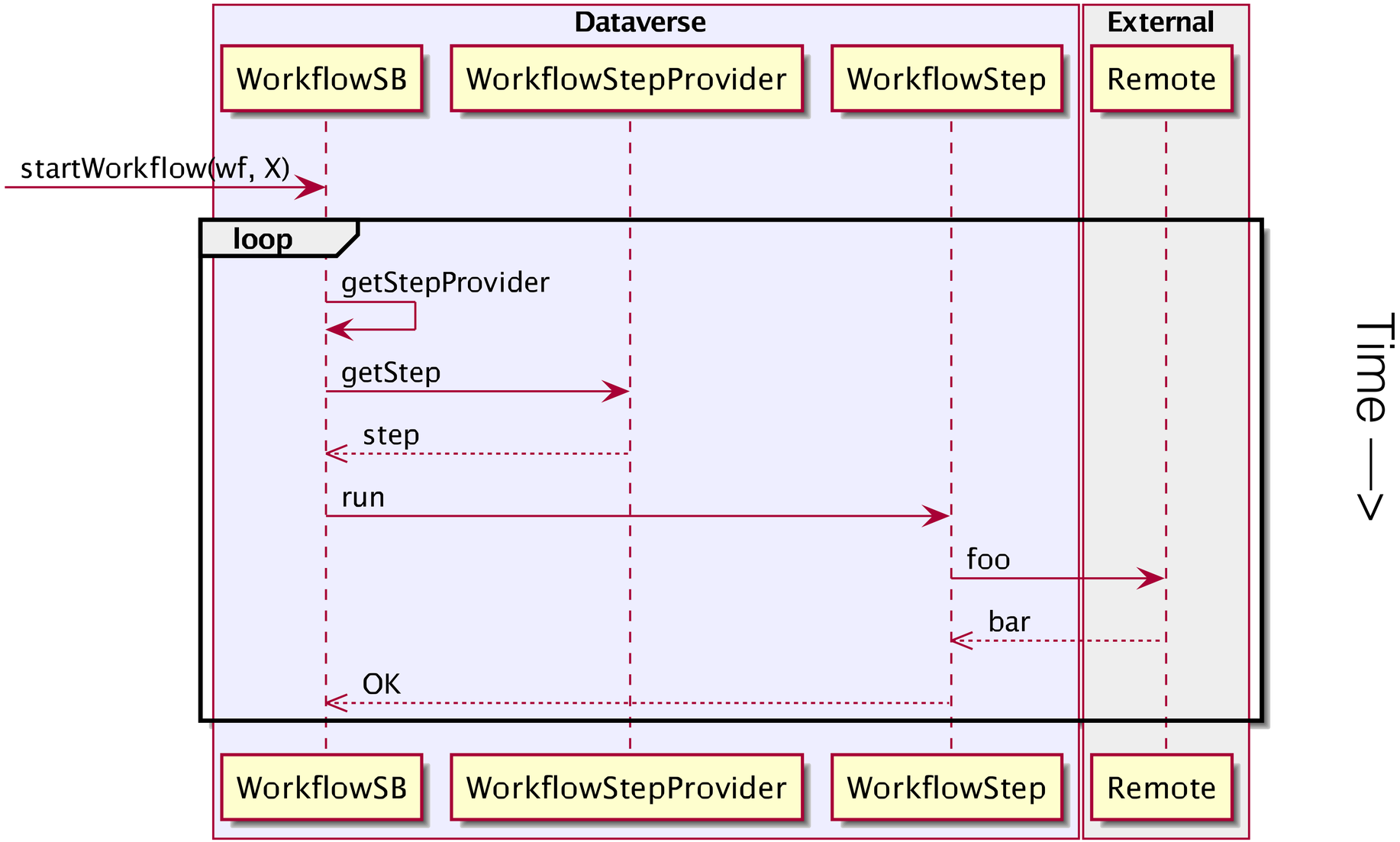
- A Workflow is a series of ***WorkflowSteps*** Stored in DB
- WorkflowSteps define methods to ***run()***, ***resume()***, and ***rollback()***
- run() can return a ***"pending" result***, which causes the workflow runtime to ***store the workflow state*** in the database
- Workflow states are ***restored*** when remote system responds
- Failed step causes the runtime to ***rollback all previous successful*** steps



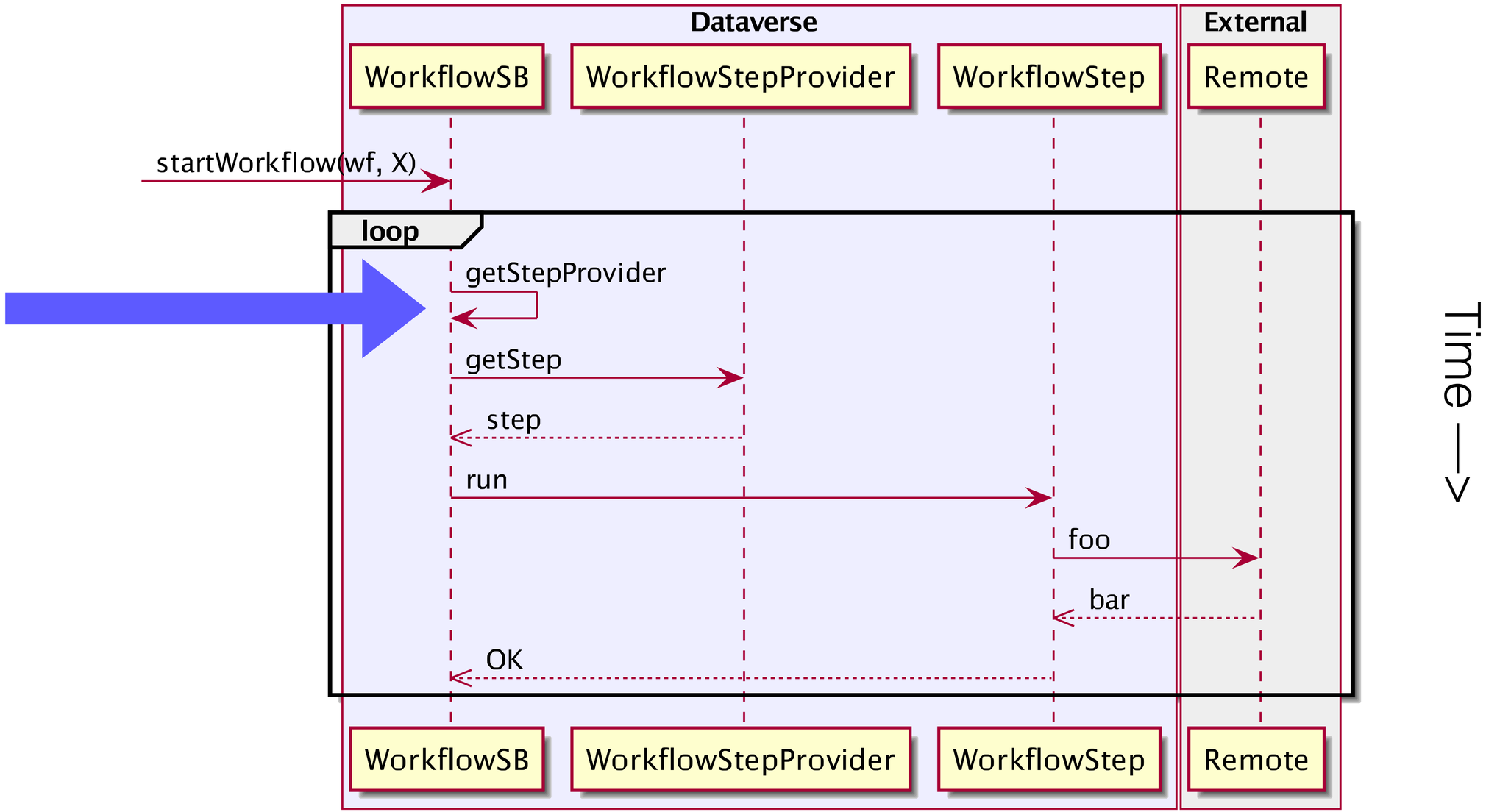
Sample WorkflowStepSPI Implementation (Plugin)

```java
@AutoService(WorkflowStepSPI.class)
public class AnnouncerWorkflowStepSPI implements WorkflowStepSPI {

    @Override
    public WorkflowStep getStep(String stepType, Map<String, String> stepParameters) {
        switch (stepType) {
            case "slack":
                return new SlackAnnouncer(stepParameters.get("username"),
                                          stepParameters.get("channel"),
                                          stepParameters.get("url"));
            case "say":
                return new SayAnnouncer();

            default:
                throw new RuntimeException("Unknown step type '" + stepType + "'");

        }
    }

}
```

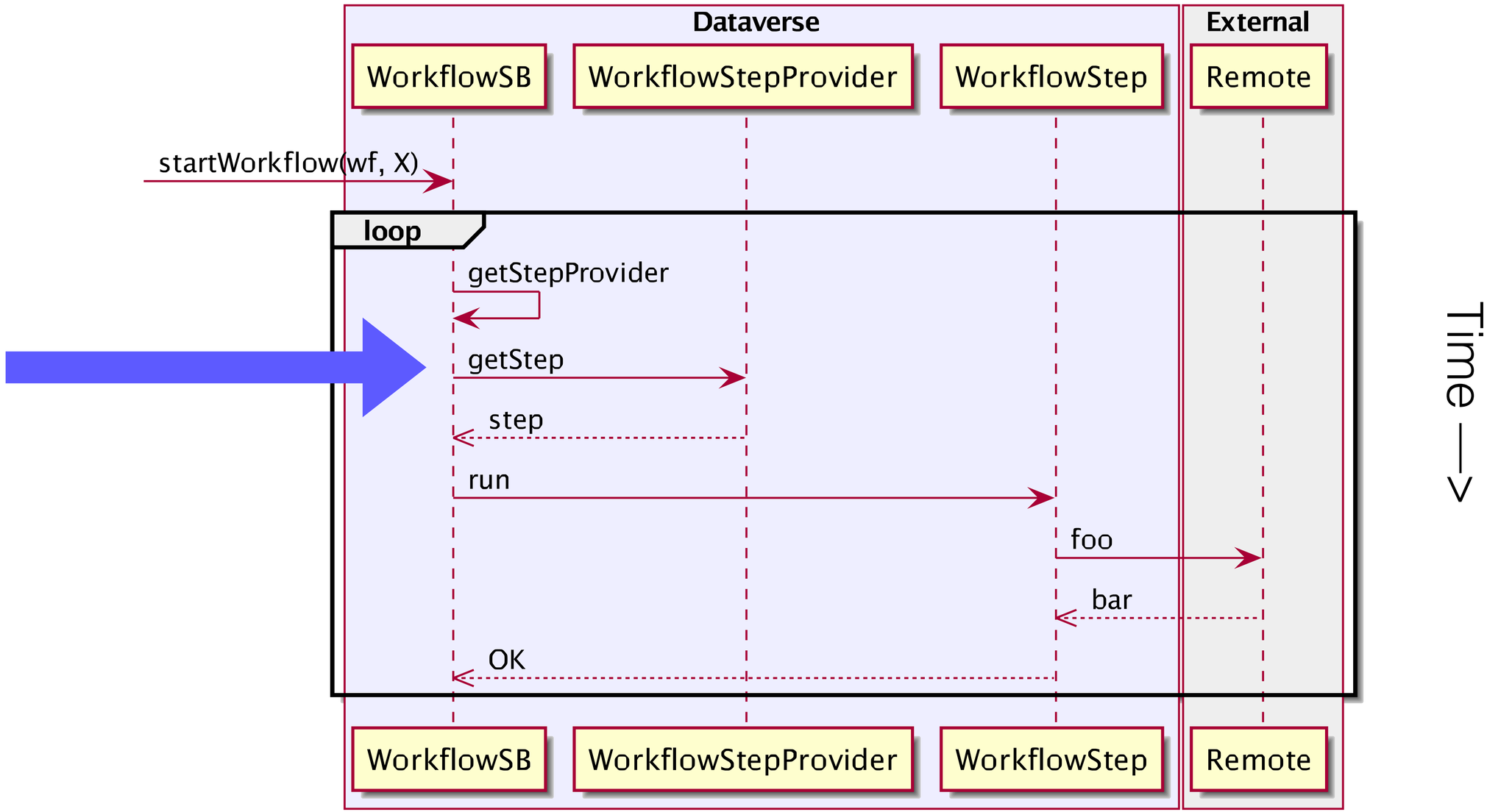
Workflow Sequence



Workflow Sequence



Workflow Sequence



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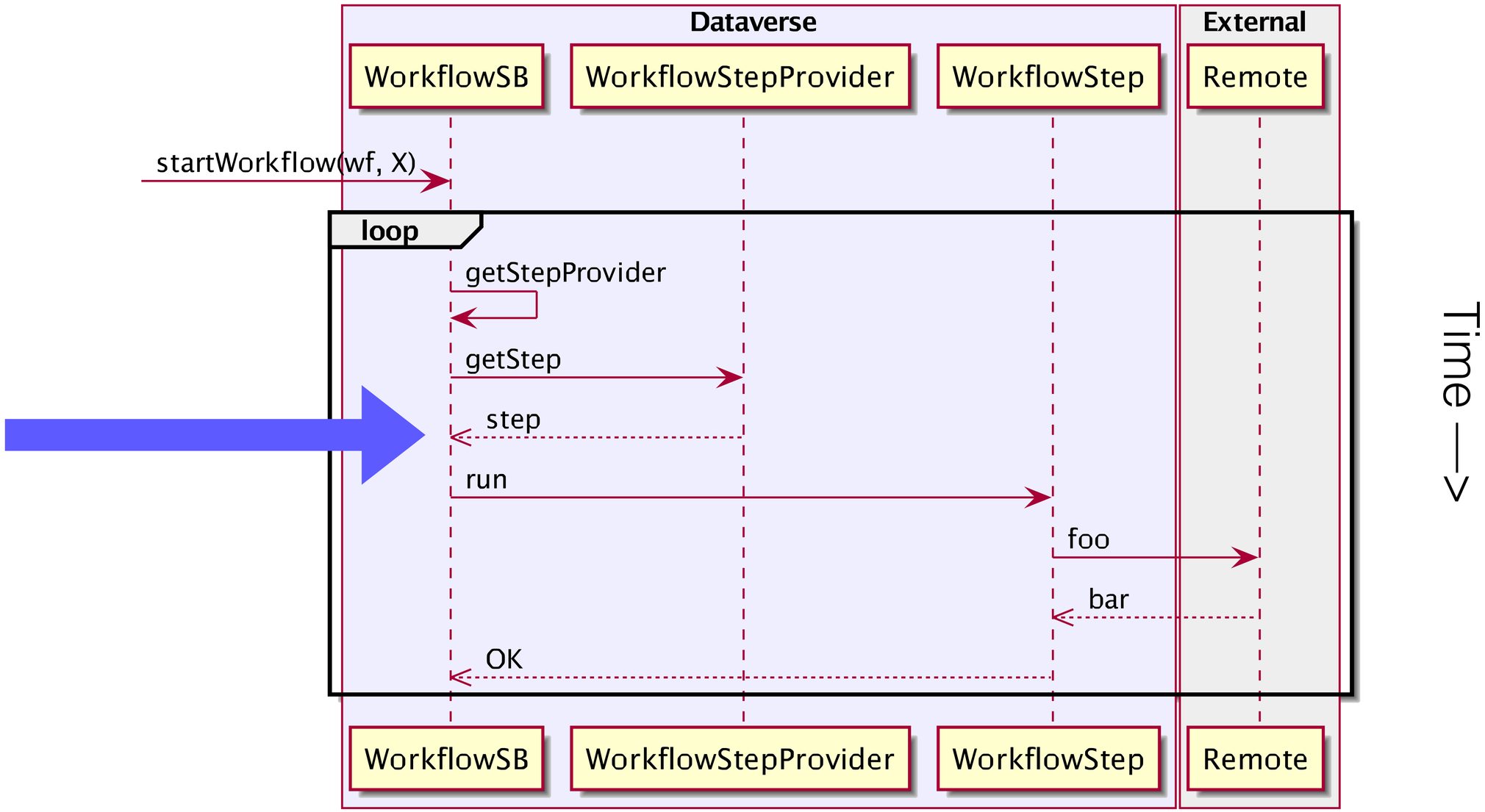

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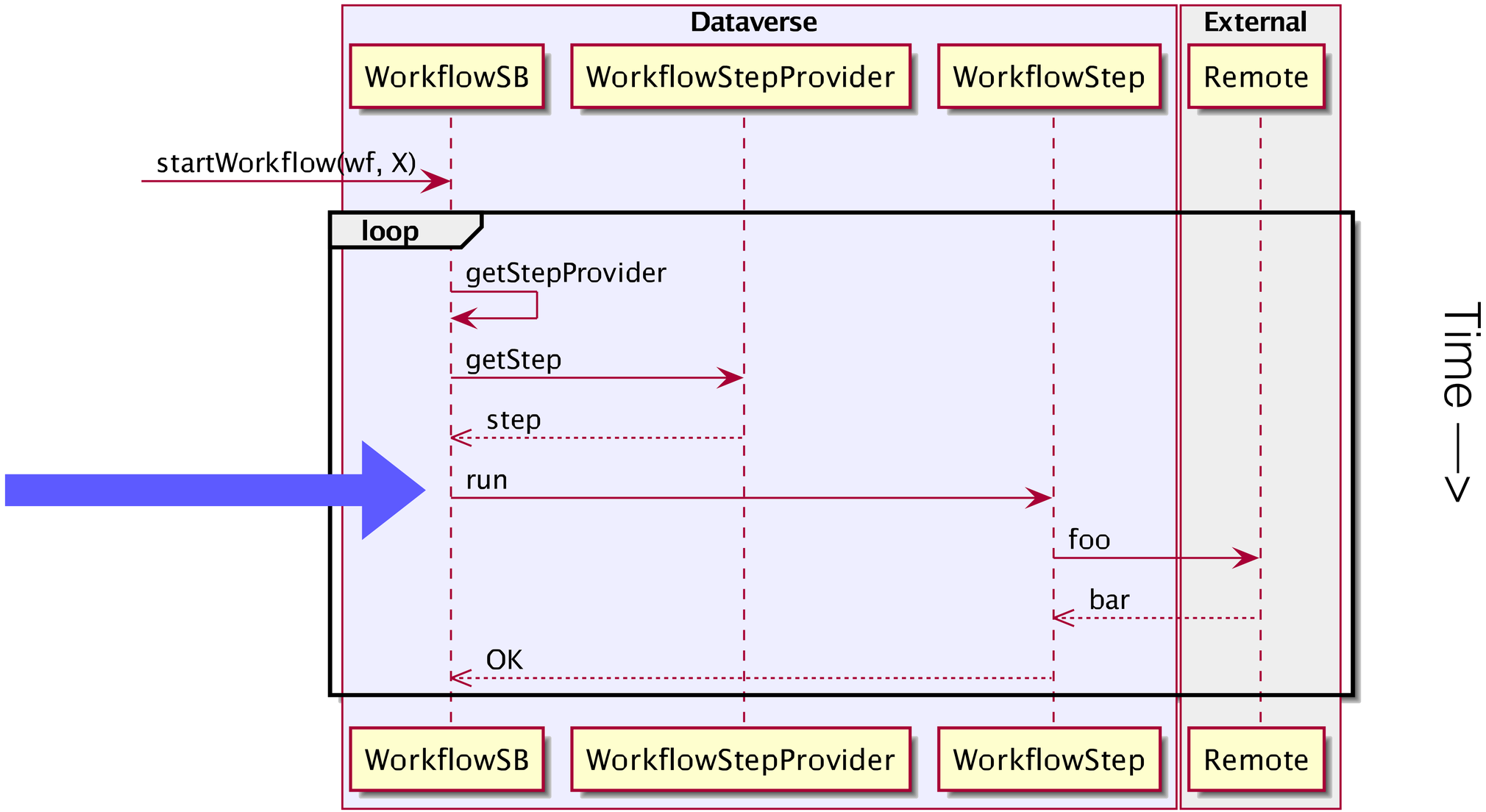

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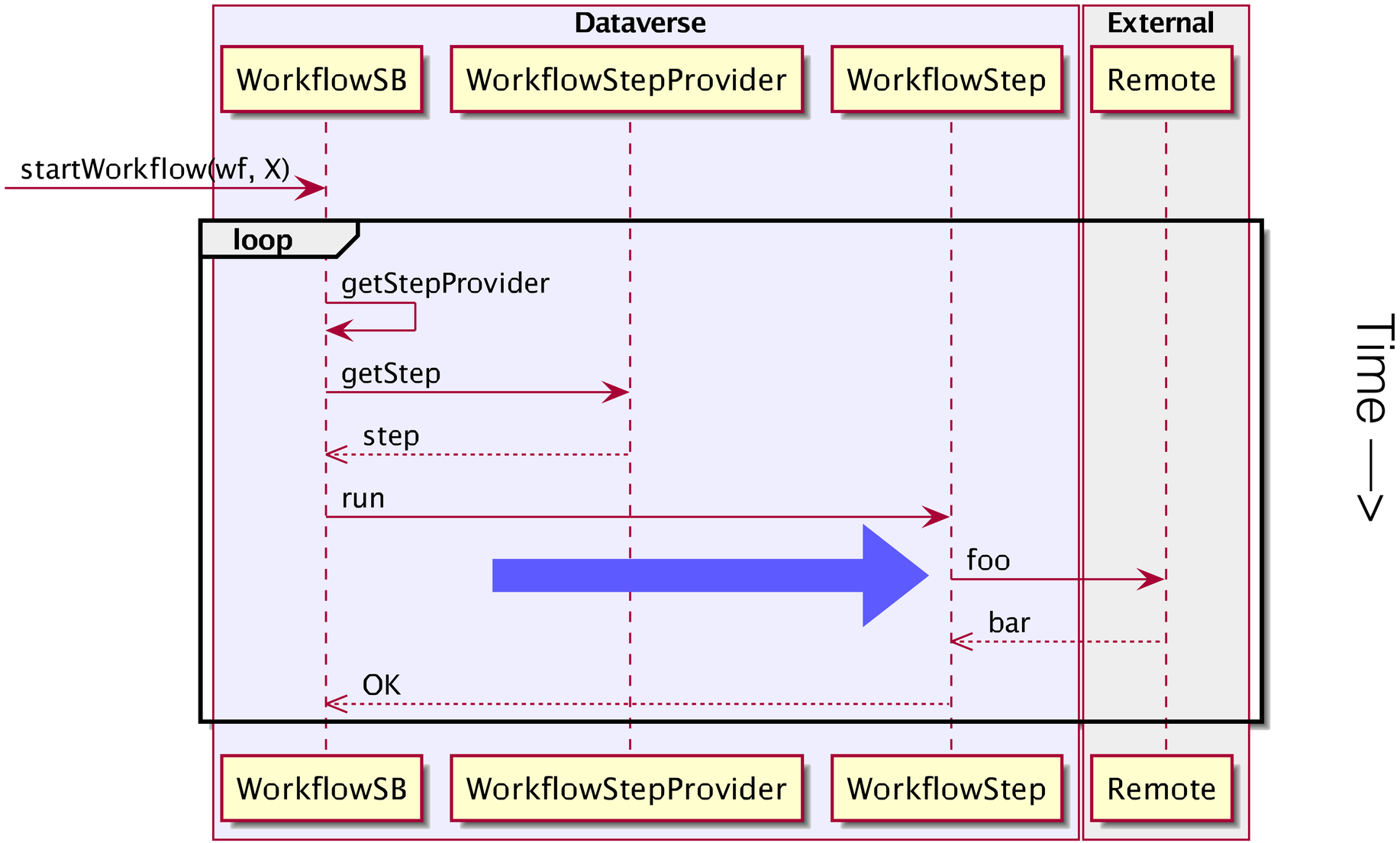

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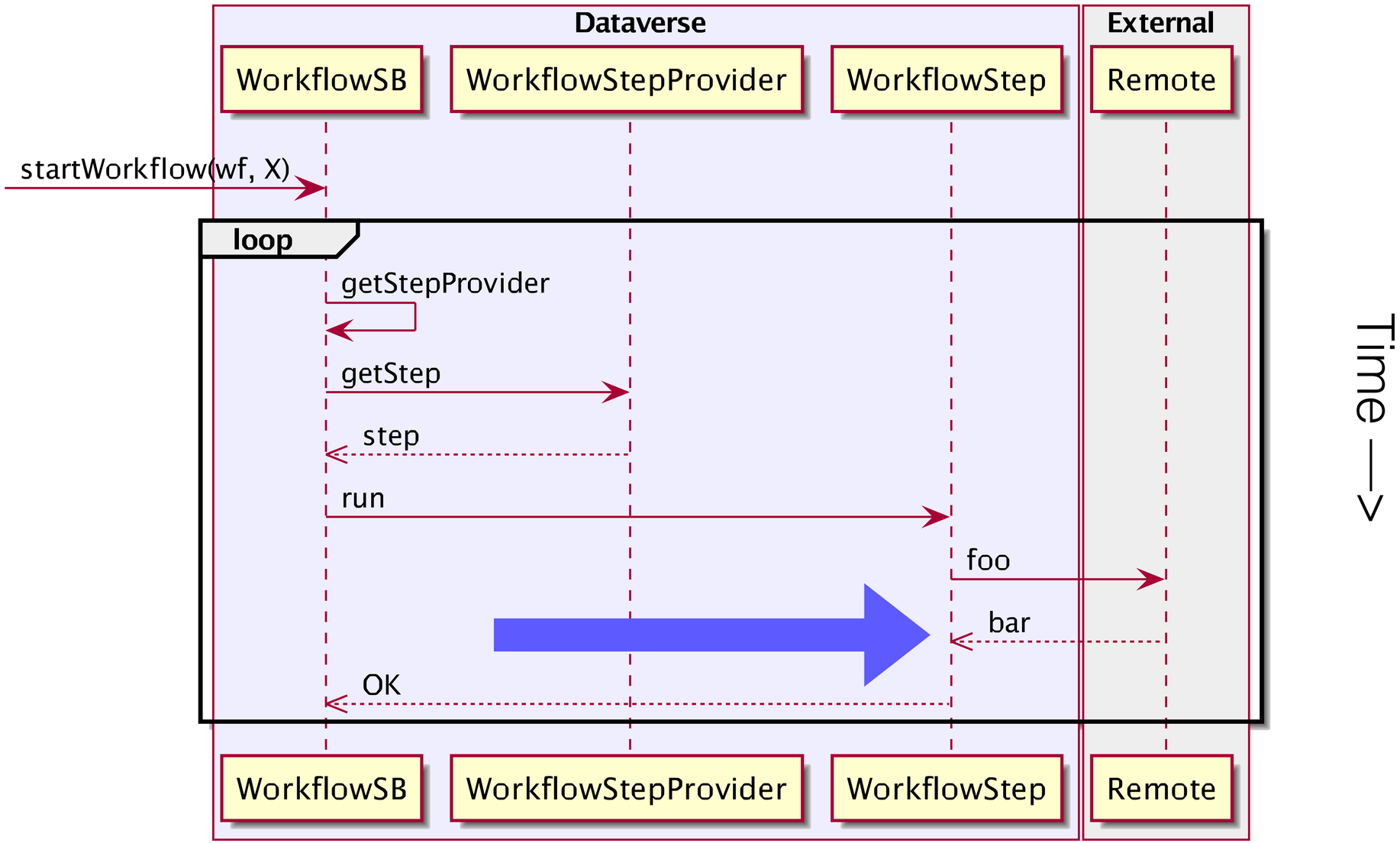

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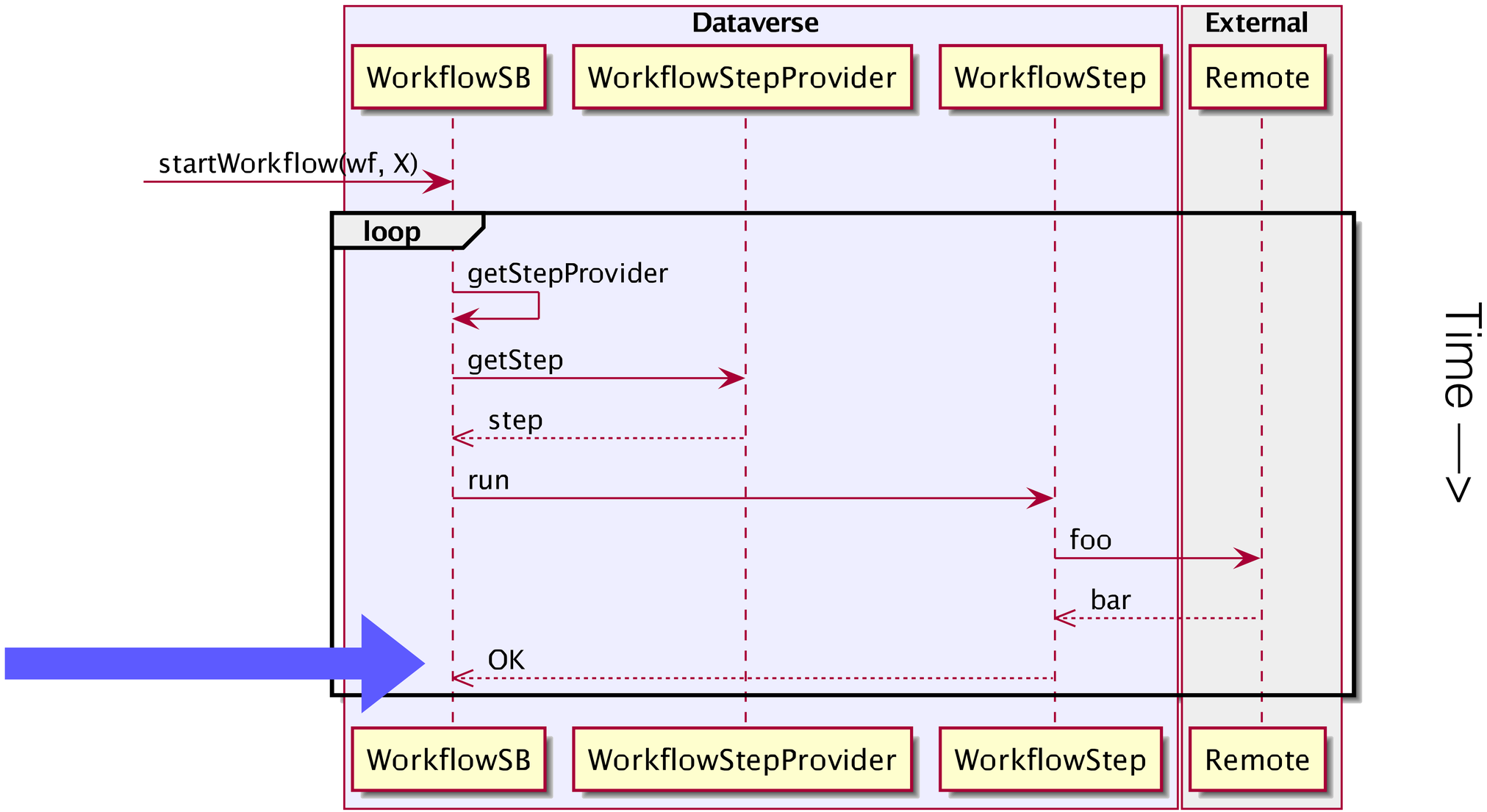

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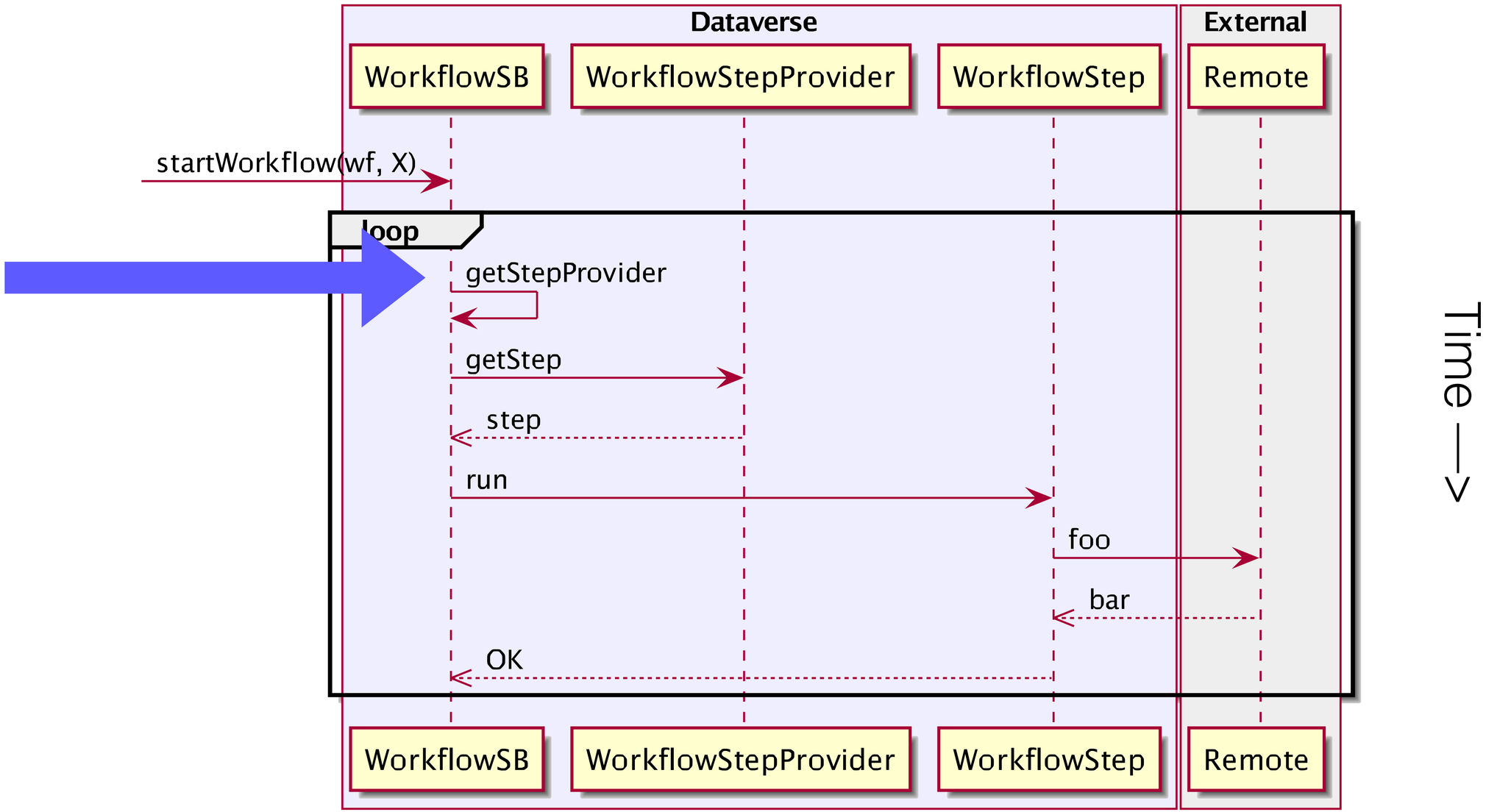

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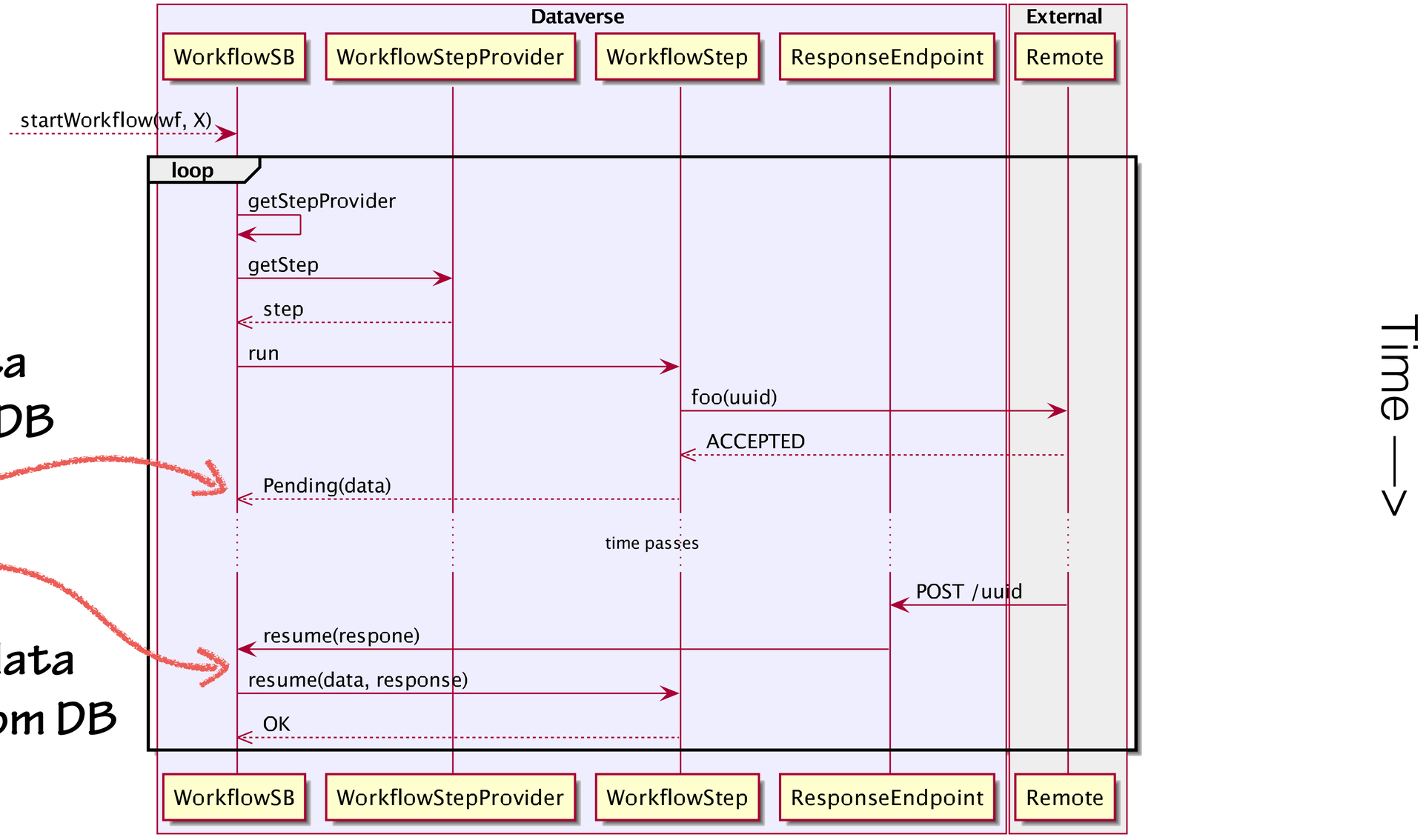
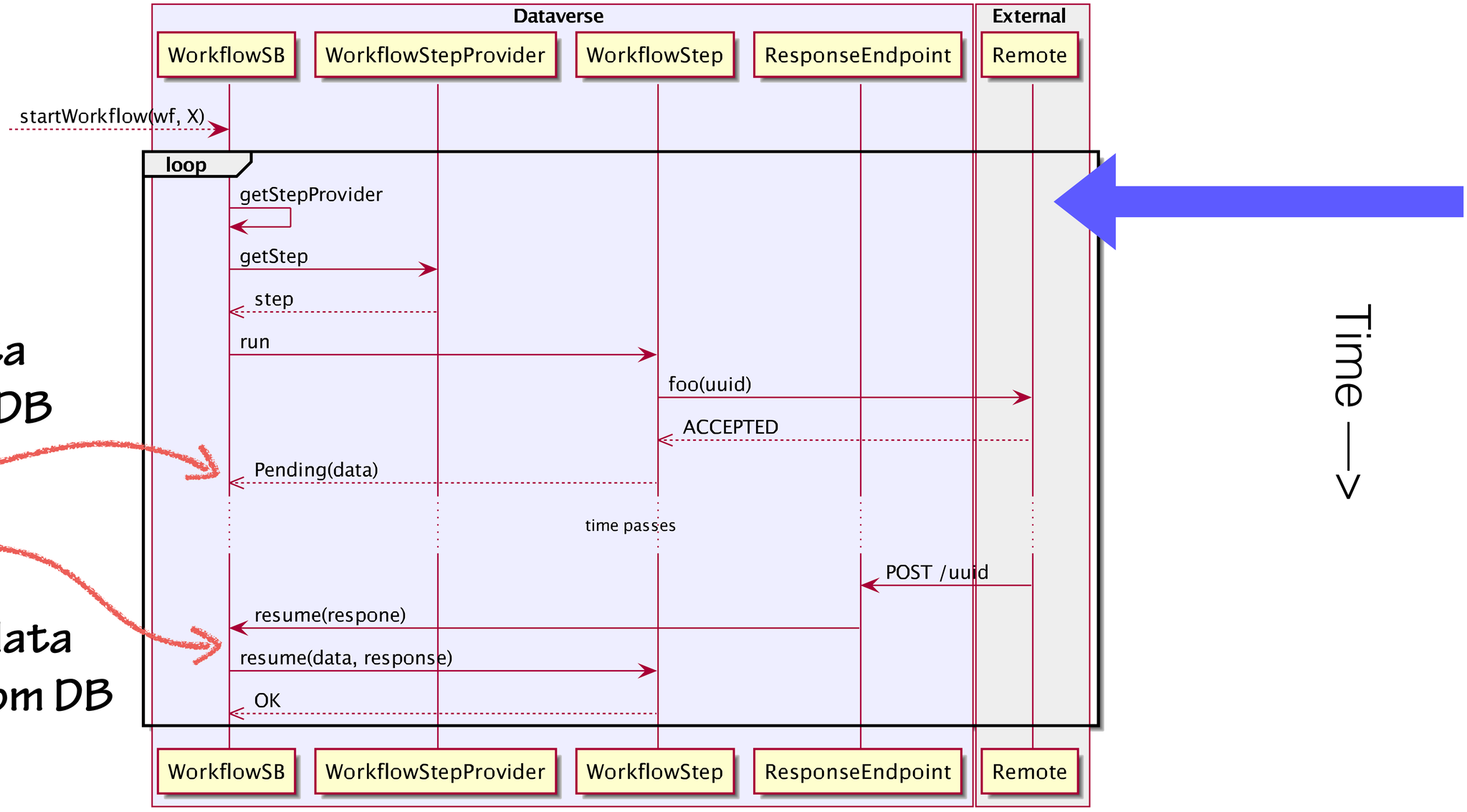


Store step data and context in DB

Restore step data and context from DB

Time —>

Workflow Sequence



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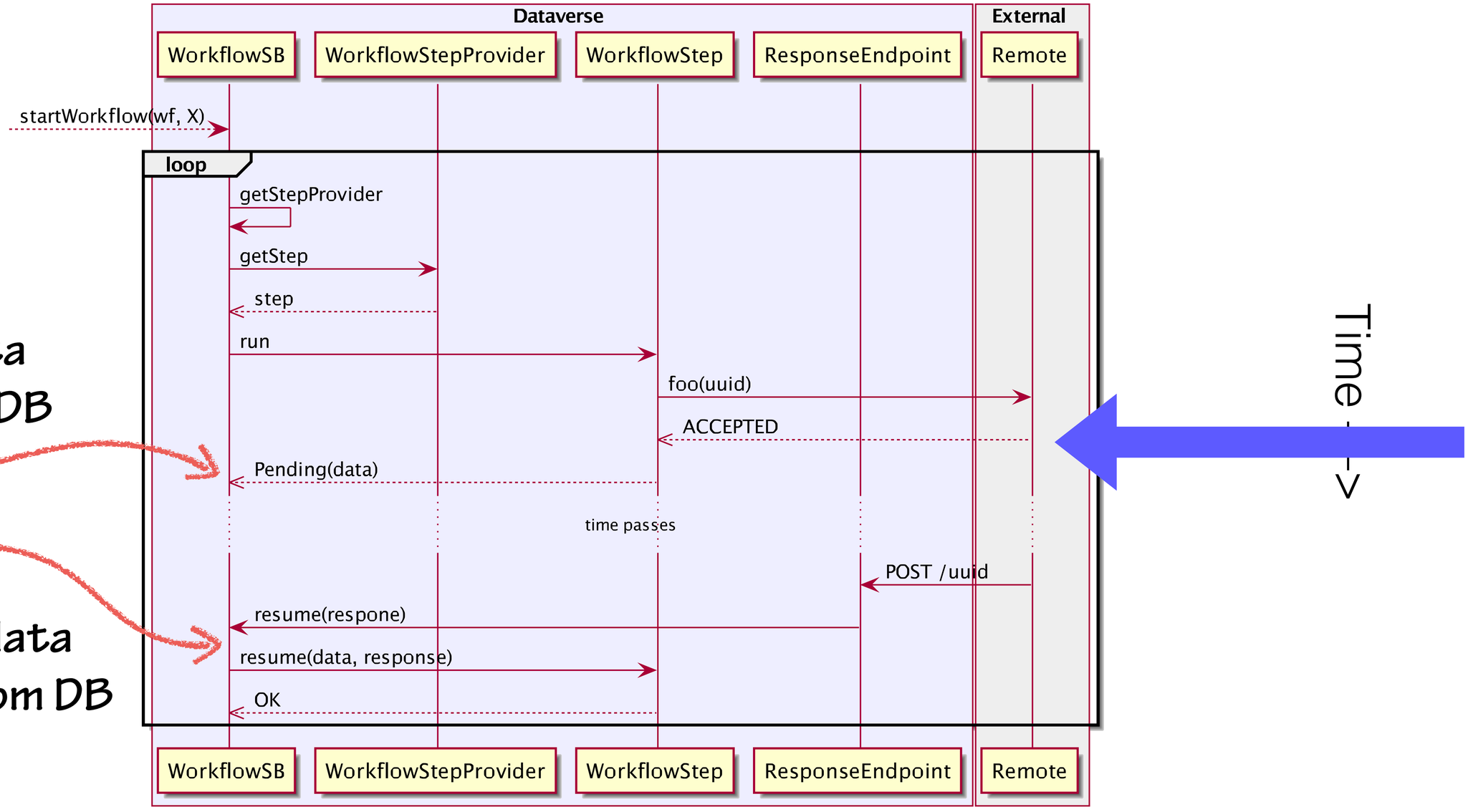

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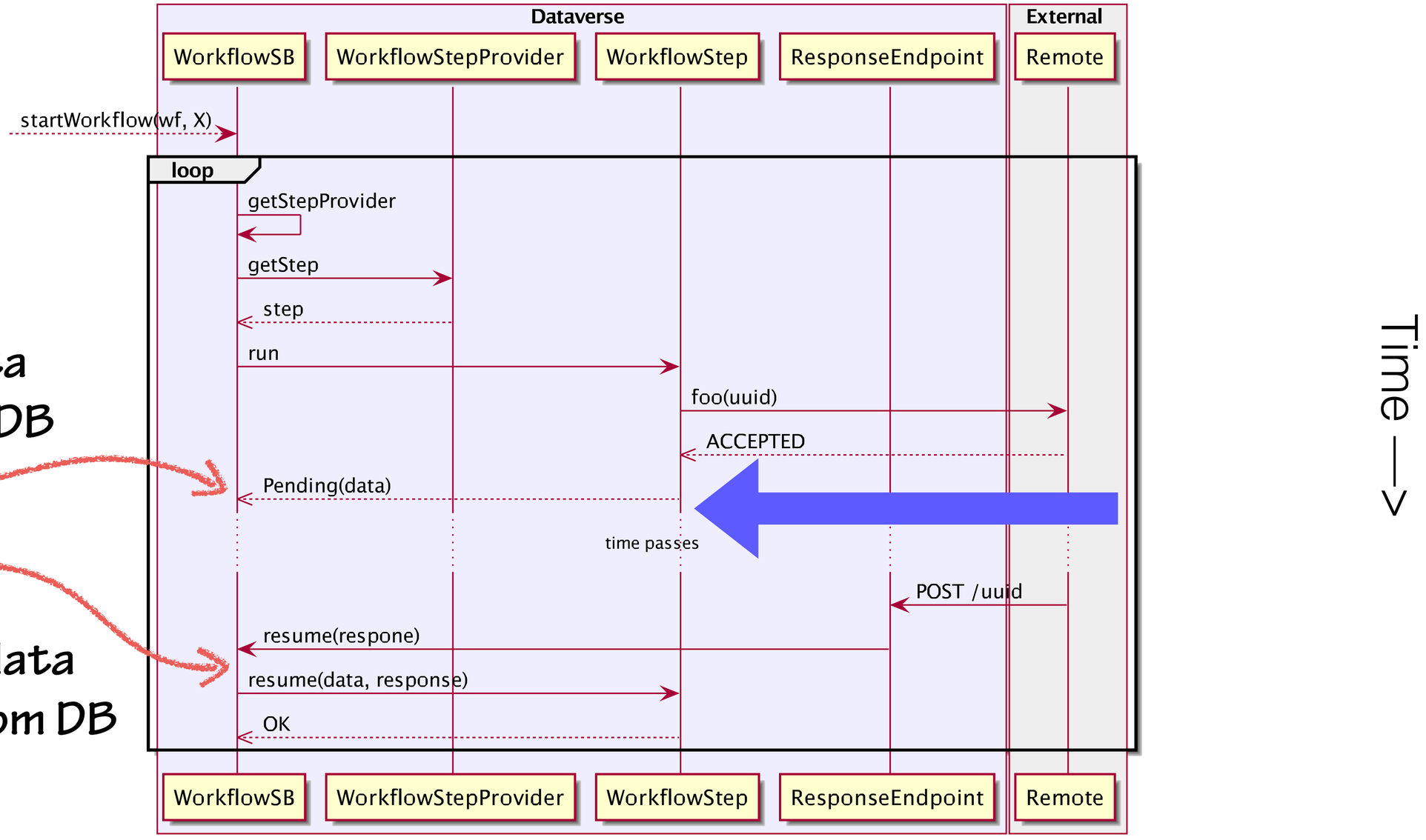

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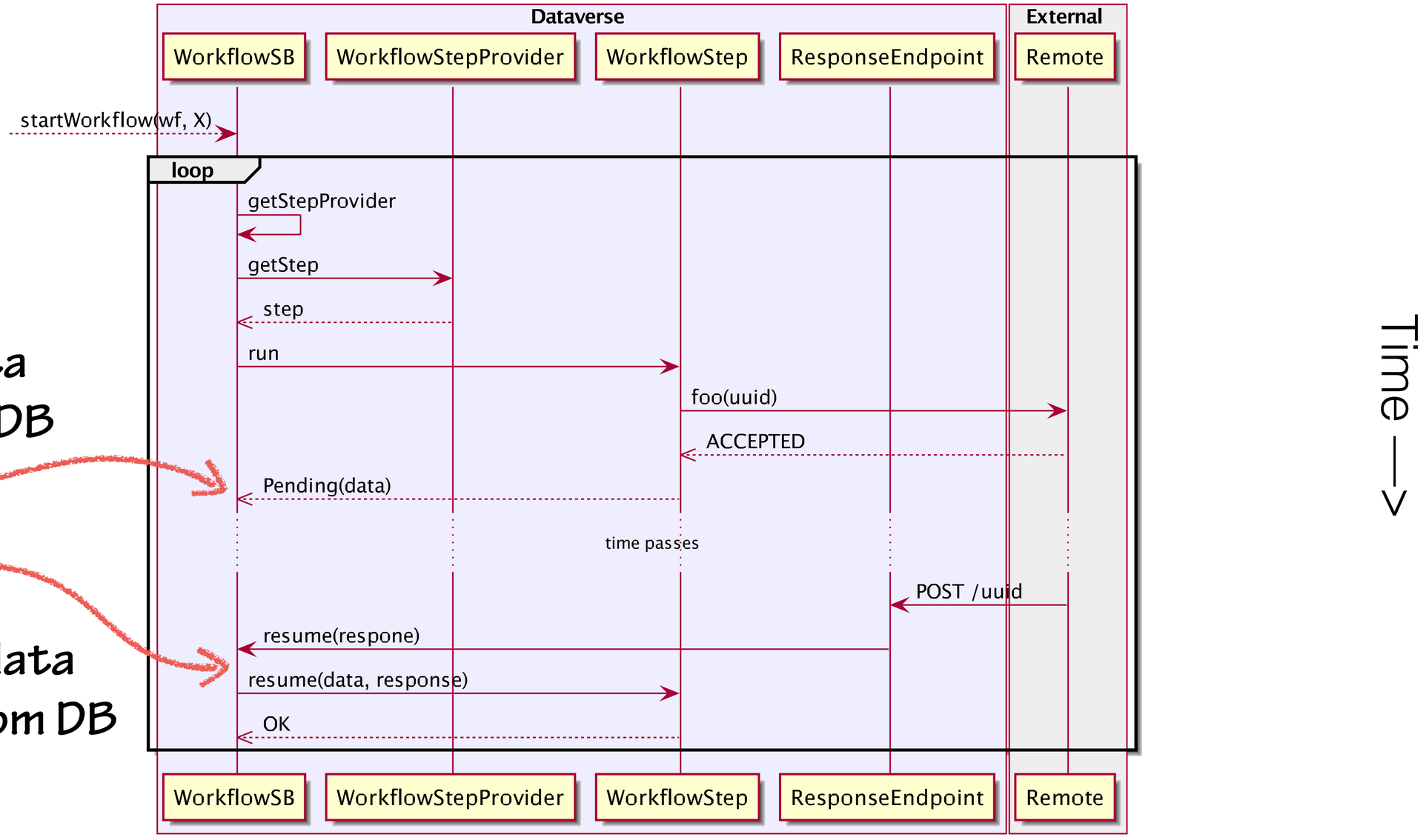

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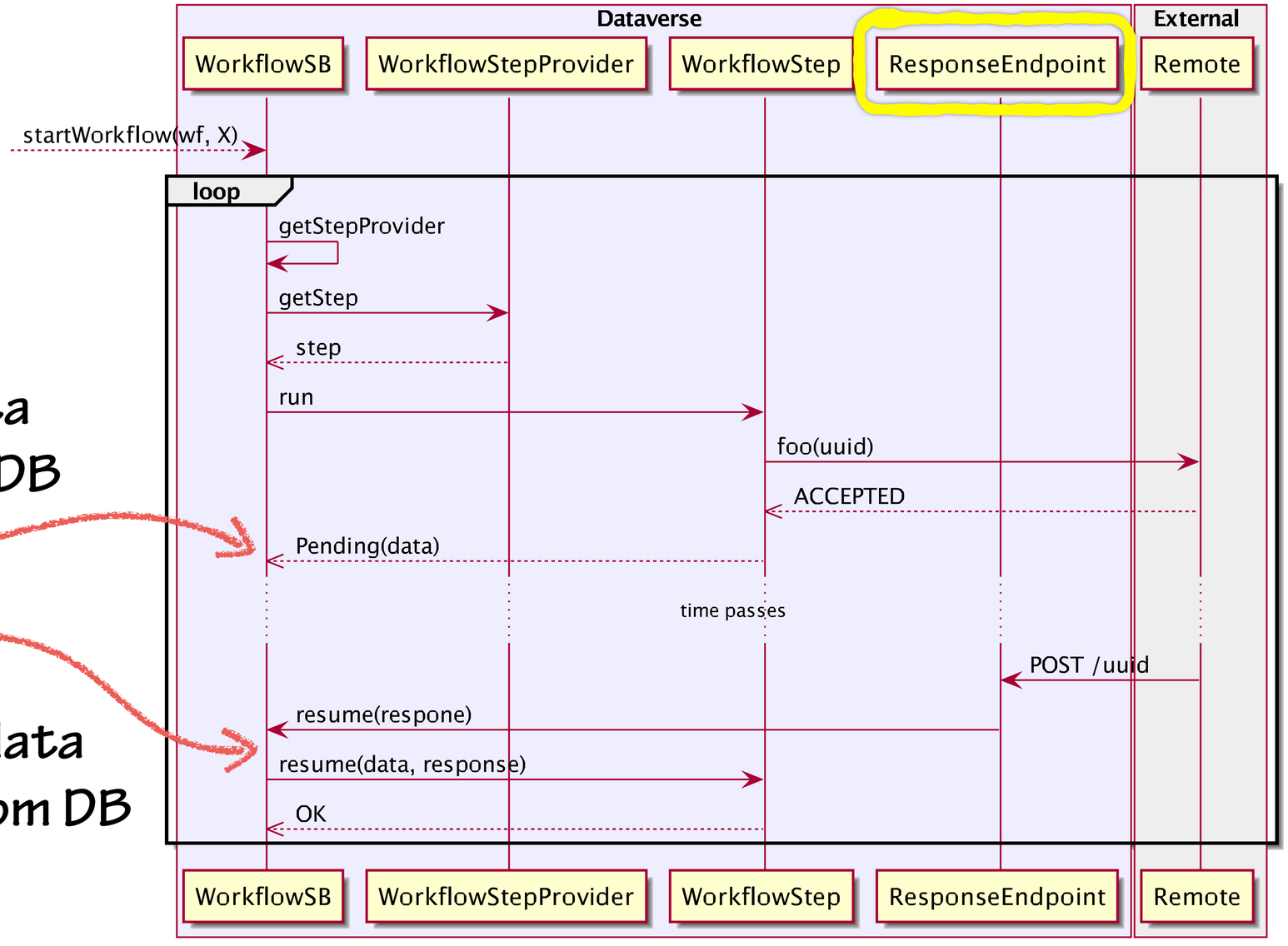

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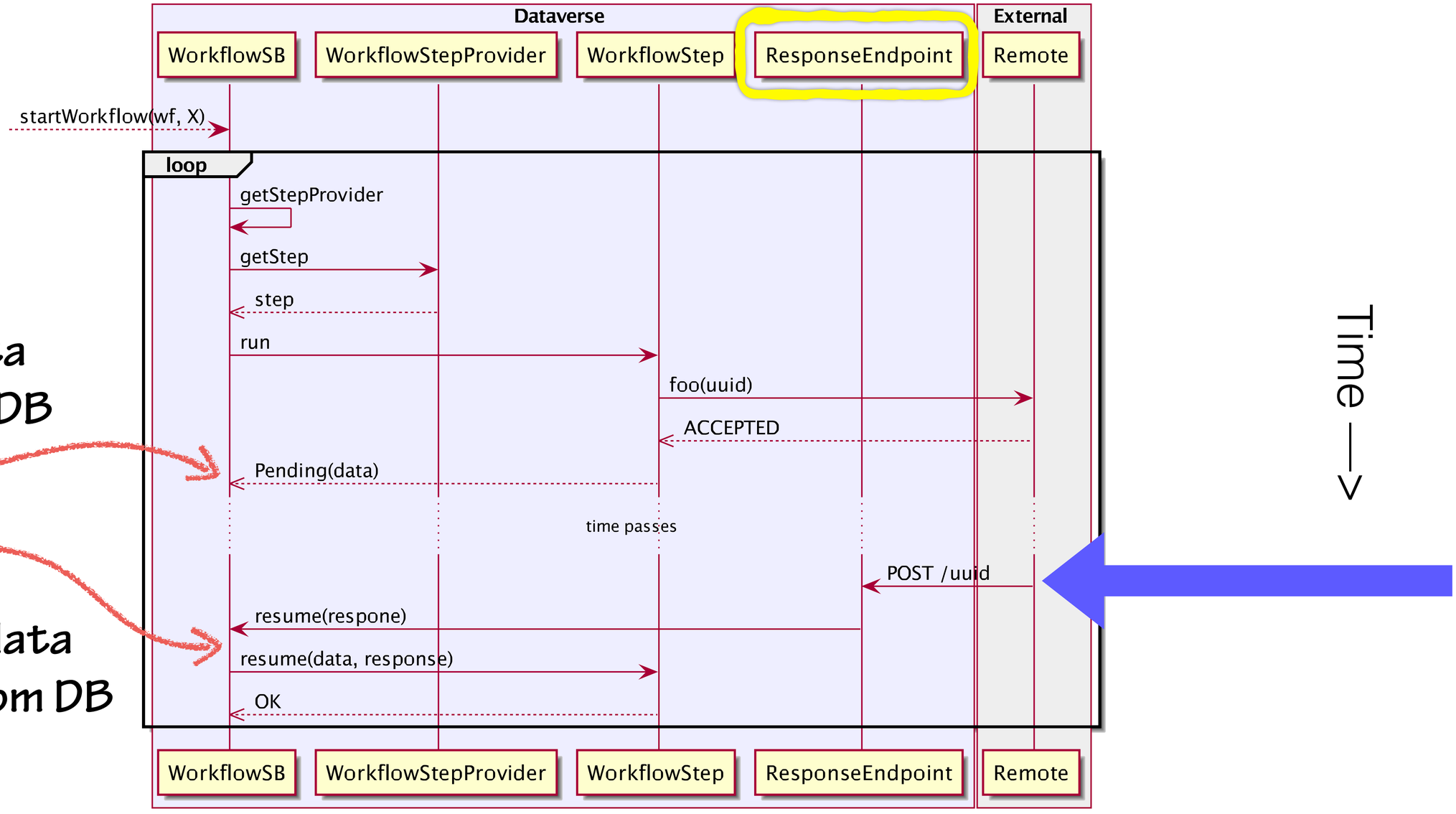

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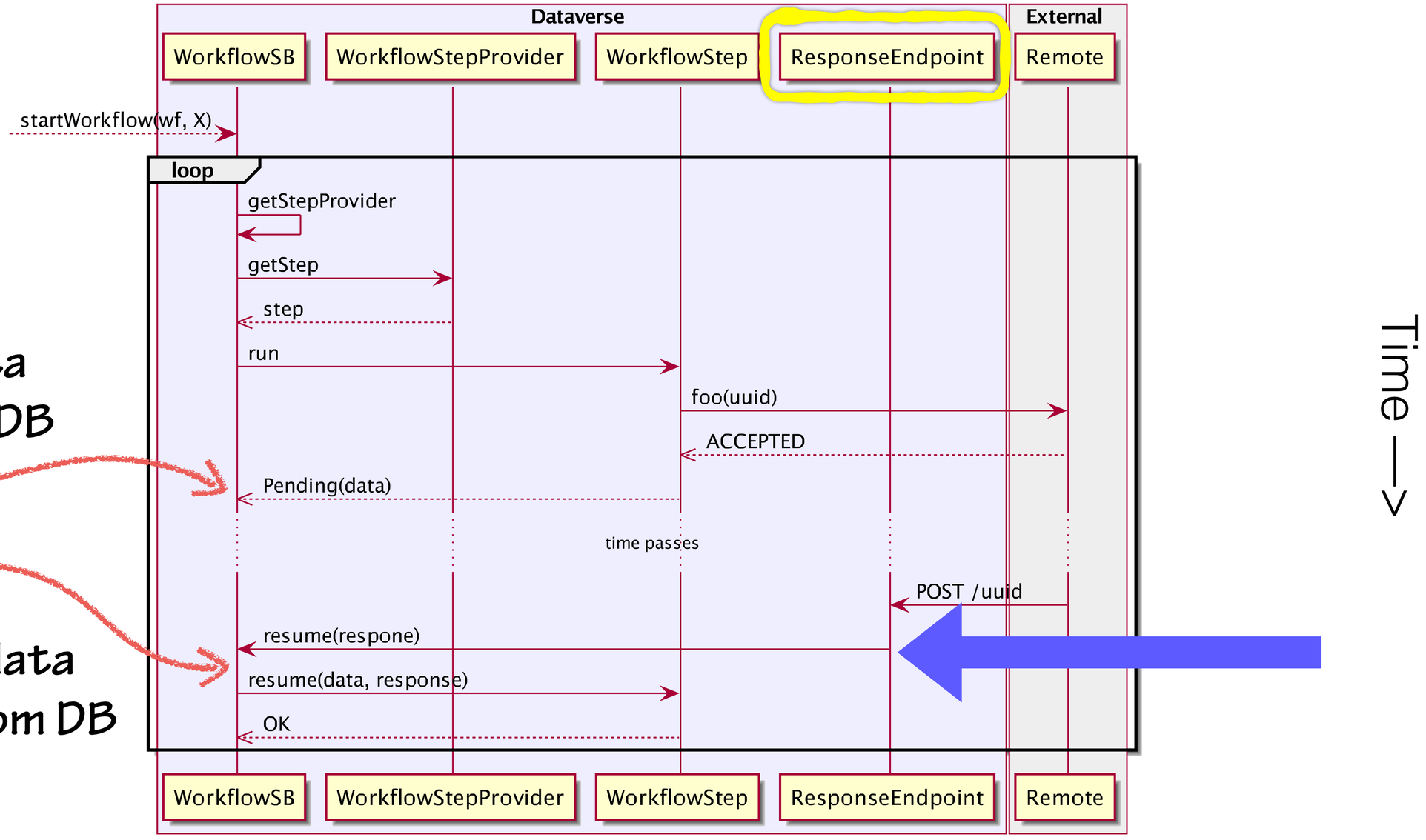

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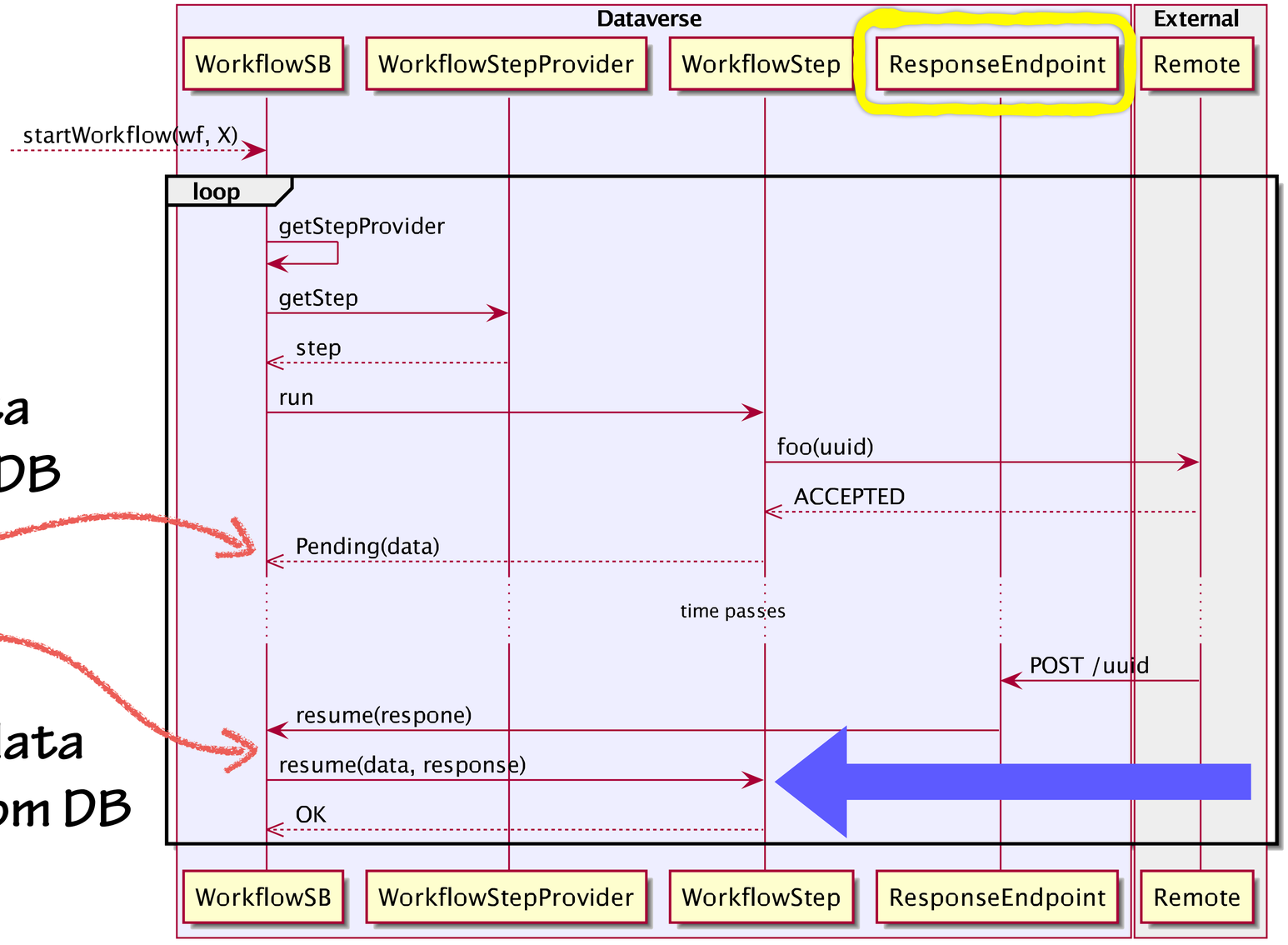

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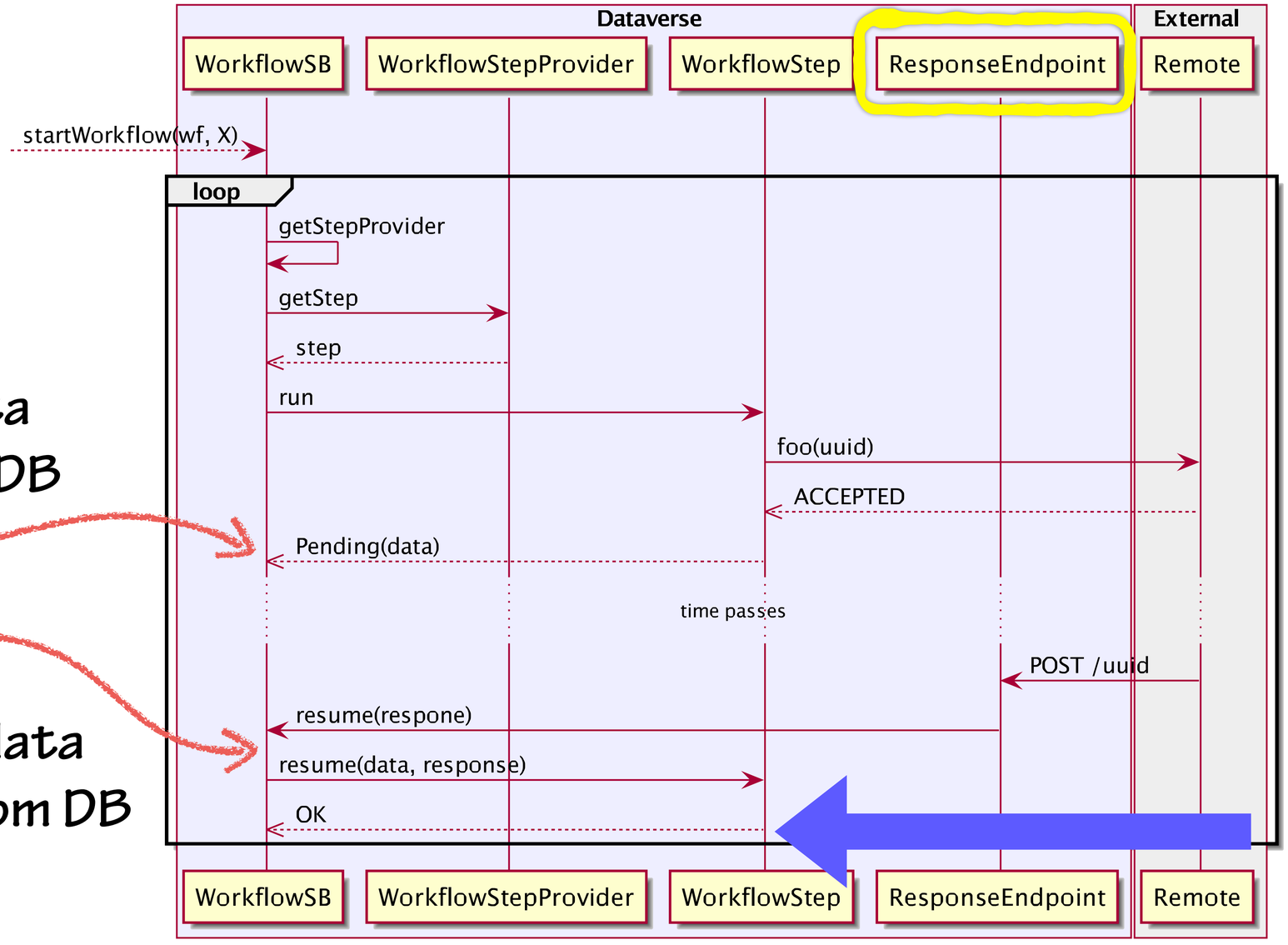

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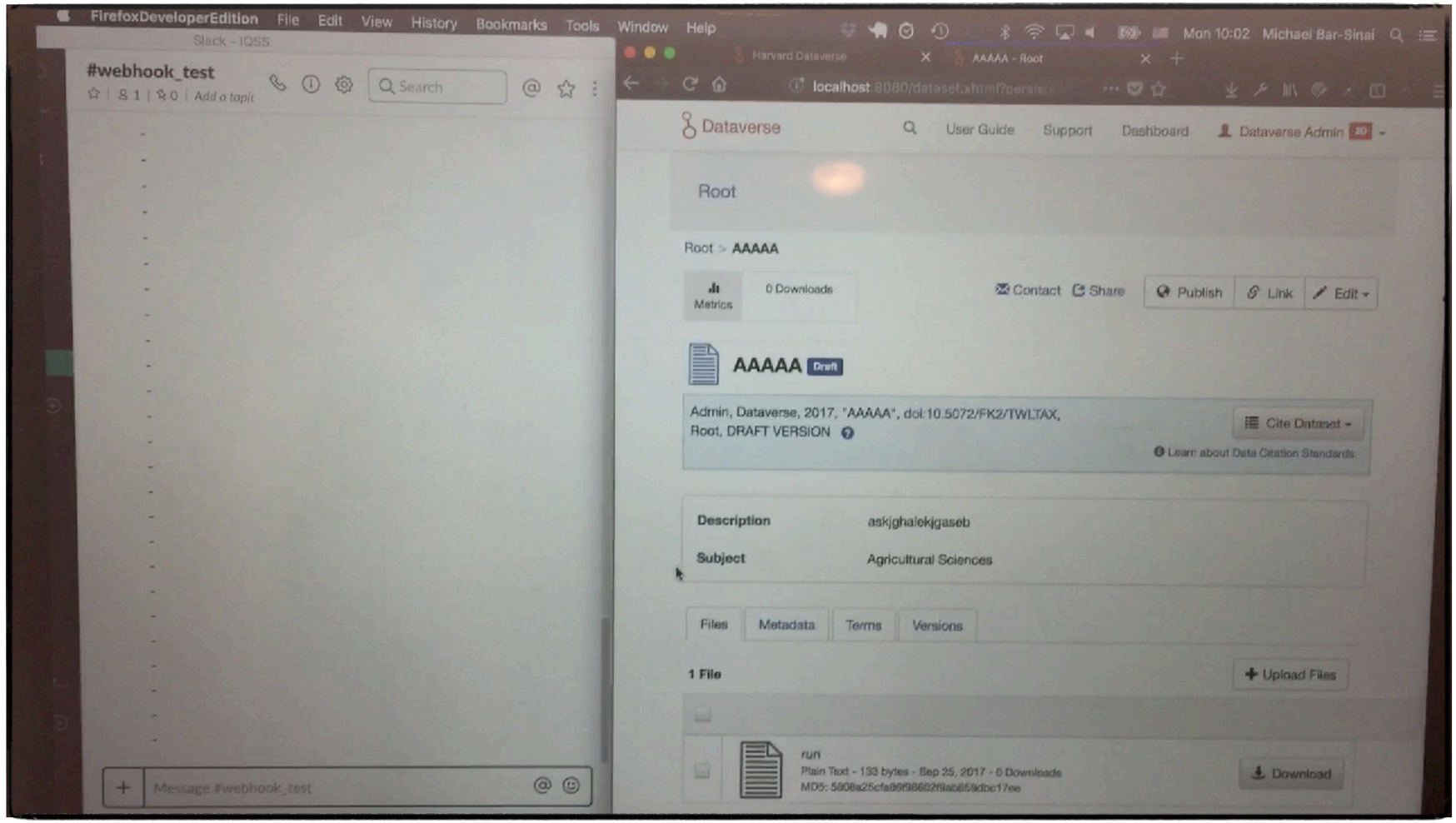
Time —>

…But Does It Work?



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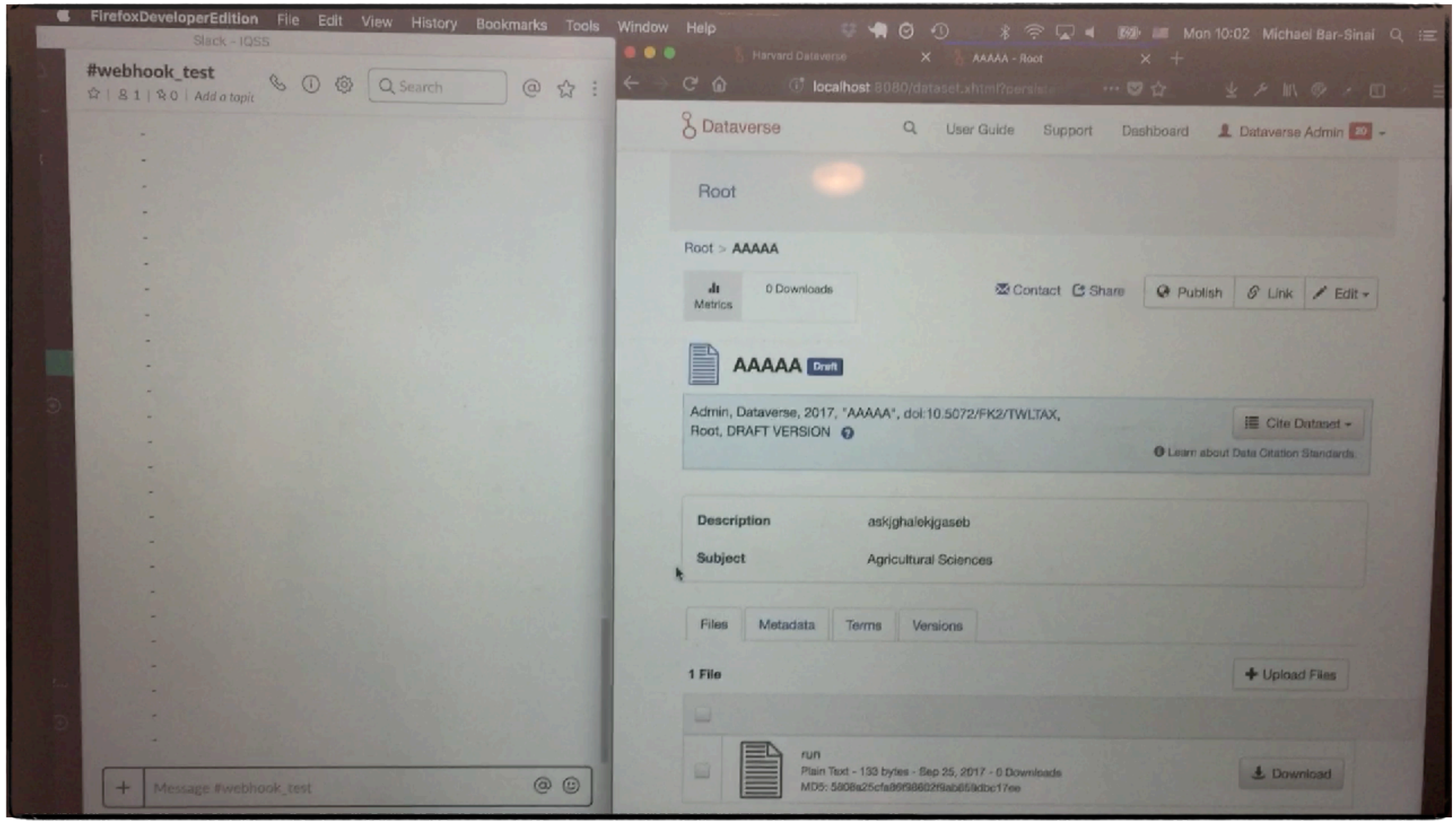


Workflow Mix

plugin + config + external standards

Codebase

- ✔ Size can go down as functionality is moved out
- ✔ Extension via configuration
- ✘ Need to add Infrastructure

Headache

- ✔ Empowers the community to add functionality on its own
- ✔ Core team not aware of remote systems at all
- ✘ A new public interface to maintain
- ✘ Security and stability may be an issue

Honorary mention

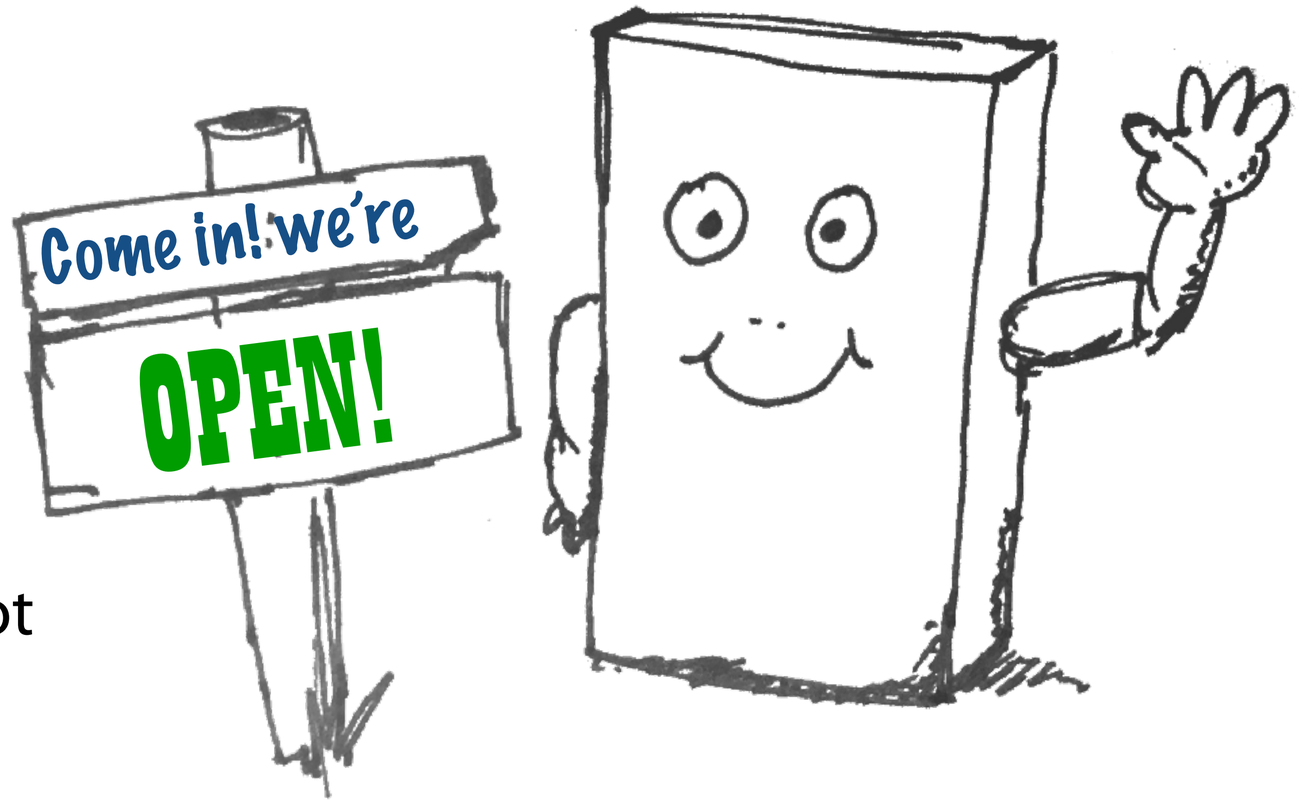
Nashorn and running user scripts

Summing Up

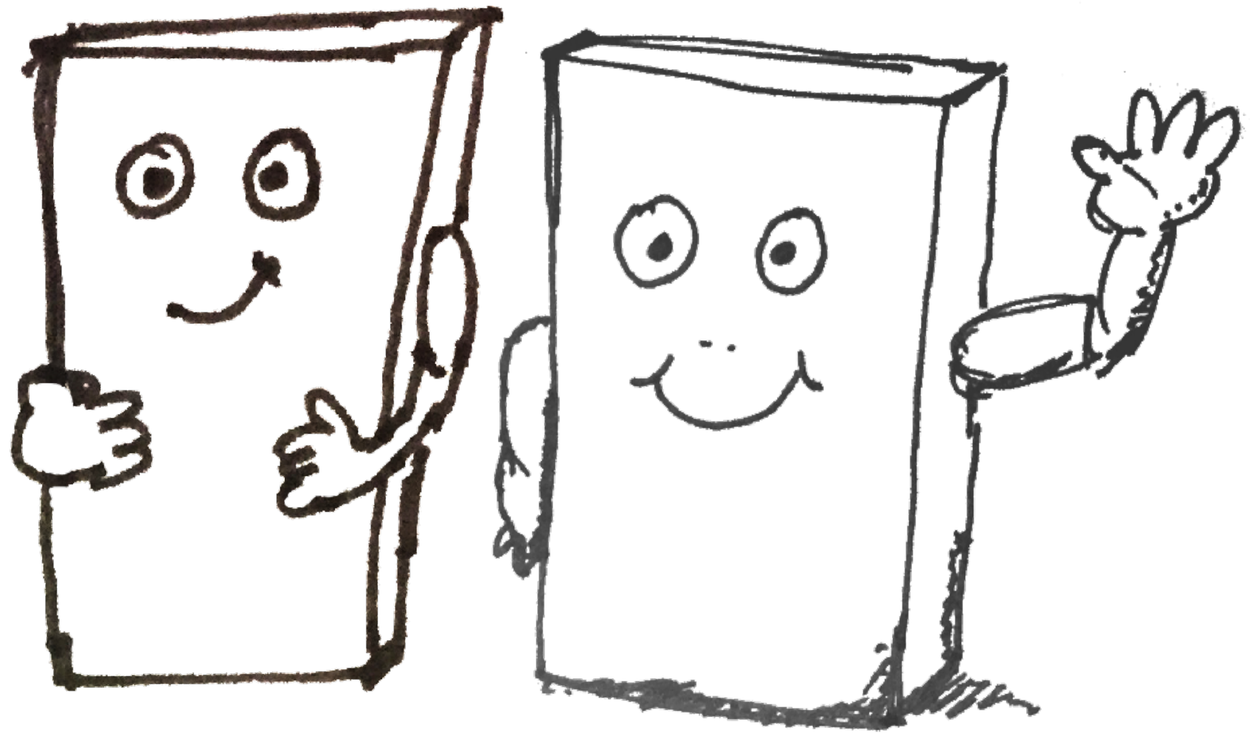
- Fun side effect: Modularization makes you think about your application and what parts of it are the core.

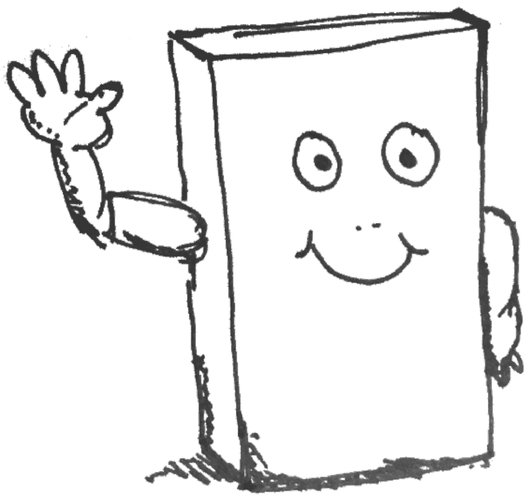
- There is a middle ground between Monolithic and MicroServices

- Each project can find its own sweet spot



Questions?

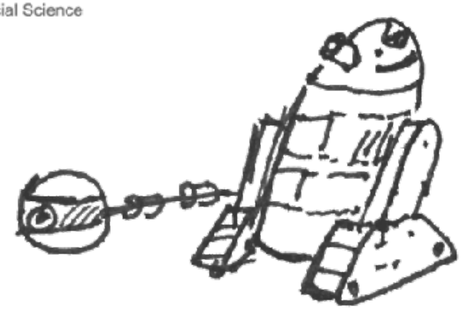




The Dataverse® Project

Thanks!

IQSS
The Institute for Quantitative Social Science



More IQSS Sessions at JavaOne 2017:

- BOF1594: **Introduction to Spark Streaming for Real Time Data Analysis**
  - Bob Treacy and Ellen Kraffmiller, Moscone West - Today, Room 2022 6:30-7:15pm
- BOF3429: **Herding Cats: Harvard Dataverse's Approach to Technical Community Management**
  - Gustavo Durand and Danny Brooke, Moscone West - Tomorrow, Room 2022 6:30-7:15pm
- BOF2805: **How to Run a Successful Open Source Java EE Project**
  - Philip Durbin and Stephen Kraffmiller, Moscone West - Tomorrow, Room 2022 Date: 7:30-8:15pm