DARE: sustained power from abstraction and mapping

at
Creating platform-driven eInfrastructure innovation on EOSC

NCSR Demokritos campus

Malcolm Atkinson, University of Edinburgh

10 July 2019
Outline

• Vision and Goals
• Key insights
• Architecture
• Achievements and Work in Progress
Vision
Vision

• Growth unlimited and sustained
  • Data
  • Computation
  • Complexity
Vision

• Growth unlimited and sustained
  • Data
  • Computation
  • Complexity
• Challenges demanding and urgent
Vision

• Growth unlimited and sustained
  • Data
  • Computation
  • Complexity
• Challenges demanding and urgent
• Conserving scarce resources
  • Human intellectual effort
  • Willingness to collaborate
  • Energy / GHG emissions

Extreme data
analytics, streaming, compression

Extreme complexity
abstraction, reproducibility, communication

Extreme computing
targeted optimisation, reflection, intelligence

DARE
driving cognition and productivity
Science and collaborations

“Black Hole Image Makes History; NASA Telescopes Coordinated Observations”

A black hole and its shadow have been captured in an image for the first time, a historic feat by an international network of radio telescopes called the Event Horizon Telescope.

“Collaboration is the key to cancer research”

To fight the disease effectively, researchers from across the scientific spectrum and beyond must join forces.

2018, Neal Savage

“Science is powerful”

Science can solve some of the world’s most complex problems, but only when the best ideas are brought together.

#TogetherScienceCan

Acknowledged Luca Trani, KNMI & EPOS

Trani, PhD Viva, 14-05-19
Respond to community complexity

Concepts

Representations

Implementations

Concept to detail

production to innovation

Paradigm shift

New approaches

Revision of phenomena, models and methods

Steering via selection and parameters

Repeated use of automated procedures

role

learner
trainer

professional
volunteer

explorer
innovator

developer
engineer

critic
approver

governance
investigator
Respond to community complexity

- **Concepts**
- **Representations**
- **Implementations**

### Production to Innovation
- Paradigm shift
- New approaches
- Revision of phenomena, models and methods
- Steering via selection and parameters
- Repeated use of automated procedures

### People Scale
- Individuals, groups, projects or organisations
- Training sessions, real-time, PhDs, projects research infrastructures research campaigns

### Discipline
- Science domain
- Data scientists
- Mathematicians
- Data architects
- System engineers
- Managers, funders...

### Role
- Governance
- Investigator
- Motivation
- Understanding challenges
- Engineering business
- Qualification
- Evidence
Respond to community complexity

Concepts to detail

Production to innovation

Roles

Governance

Investigator

Critic

Approver

Developer

Engineer

Learner

Trainer

Professional

Volunteer

Innovator

Individuals, groups, projects or organisations

People scale

Training sessions, real-time, PhDs, projects

Research infrastructures

Research campaigns

Duration

Science domain

Data scientists

Mathematicians

Data architects

Systems engineers

Managers, funders

...

Discipline

Understanding

Challenges

Motivation

Engineering

Business

Qualification

Evidence

Embrace dynamics and diversity

Simple changes easy for all

Empower substantial innovation by experts
Deliver benefits Avoid disruption Be adopted
Deliver benefits Avoid disruption Be adopted

• Deliver stability
  • established practices unchanged
  • refined methods unchanged
  • negotiated agreements unchanged
Deliver benefits Avoid disruption Be adopted

- Deliver stability
  - established practices unchanged
  - refined methods unchanged
  - negotiated agreements unchanged
- New capabilities
Deliver benefits
Avoid disruption
Be adopted

• Deliver stability
  • established practices unchanged
  • refined methods unchanged
  • negotiated agreements unchanged

• New capabilities
• Improved productivity
Deliver benefits
Avoid disruption
Be adopted

• Deliver stability
  • established practices unchanged
  • refined methods unchanged
  • negotiated agreements unchanged

• New capabilities

• Improved productivity

• Agile response to new challenges and opportunities
Deliver benefits Avoid disruption Be adopted

- Deliver stability
  - established practices unchanged
  - refined methods unchanged
  - negotiated agreements unchanged
- New capabilities
- Improved productivity
- Agile response to new challenges and opportunities
- Riding the technology wave
Intention
refined precise
honoured persistently
domain focused
shaped by campaigns
refined precise
honoured persistently
domain focused
shaped by campaigns

maintain intention
need scope to
optimally exploit
evolving technology
Incentive

Intention

Interpretation

Implementation

refined precise
honoured persistently
domain focused
shaped by campaigns

maintain intention
need scope to
optimally exploit
evolving technology

data architecture
workflow optimisation
systems engineering
resource management
technology innovation

Outline

• Vision and Goals
• Key insights
• Architecture
• Achievements and Work in Progress
CMDC quartet plays well

- **Concepts**
  - what a communication is about
  - precise terminology
  - precise properties
  - precise relationships
- **Representations**
  - how they are communicated
- **Populations**
  - the instances in play
Clarifying the concepts in use

CRP Methodology

Application Domain Experts → Conceptual definition → Representation → Population → Information System Engineers

Data Model Experts

Acknowledge Luca Trani, KNMI & EPOS
CMDC quartet plays well

- **Methods**
  - purpose and processes
  - conceptual inputs
  - controls, parameters and active provenance
  - conceptual results delivered
- **Notations**
  - creation and refinement
  - avoid distracting detail and lock-ins
  - workflows as requests for action
- **Workloads**
  - testing & validation
  - steered production
  - automated routine
CMDC quartet plays well

• **Methods**
  • purpose and processes
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  • controls, parameters and active provenance
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• Notations
  • creation and refinement
  • avoid distracting detail and lock-ins
  • workflows as requests for action

• Workloads
  • testing & validation
  • steered production
  • automated routine

Virtualisation for capabilities and cost saving
Immediate local action for testing
CMDC quartet plays well

• Data
  • primary, intermediate, evidential
  • from human input, instruments, observations, simulations and analyses
  • often standardised imperfectly
  • every possible diversity
• Organisation and structure
  • data models, metadata, storage systems, databases, document, latent
  • optimised encodings
• Populations
  • many, many instances growing in diversity, number and size
CMDC quartet plays well

• Data
  • primary, intermediate, evidential
  • from human input, instruments, observations, simulations and analyses
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Virtualisation for feasibility and cost saving
Local control for user judgement
CMDC quartet plays well

- **Collections**
  - users create, build, manage and use them
  - software works with them
- **Representation**
  - sets, bags, tuples, trees, sequences, time series, …
  - optimised encodings, scientific databases
- **Populations**
  - many instances growing in diversity, number & size
CMDC quartet plays well

- **Collections**
  - users create, build, manage and use them
  - software works with them
- **Representation**
  - sets, bags, tuples, trees, sequences
  - optimised encodings, scientific databases
- **Populations**
  - many instances growing in diversity, number & size

Virtualisation for engineering and cost saving
Local control for user engagement
Keep CMDC in harmony
Keep CMDC in harmony for all in a community
Specialised *but related* work contexts
Specialised *but related* work contexts

- Delivering CMDC
Specialised *but related* work contexts

- Delivering **CMDC**
- Focused and tuned
  - for each community
Specialised *but related* work contexts

- Delivering **CMDC**
- Focused and tuned
  - for each community
  - for each sub community
Specialised *but related* work contexts

- Delivering **CMDC**
- Focused and tuned
  - for each community
  - for each sub community
  - for each discipline / role
  - for groups and individuals

**CMDC Concepts, Methods, Data and Collections**
Specialised *but related* work contexts

- Delivering **CMDC**
- Focused and tuned
  - for each community
  - for each sub community
  - for each discipline / role
  - for groups and individuals
- Context-sensitive API
  - for VREs, tools & GUIs
Outline

• Vision and Goals
• Key insights
• Architecture
• Achievements and Work in Progress
DARE users create, use, refine and discard

Others + DARE future: Tools & User interfaces

DARE API & Development kit

DARE Platform

DARE Data-Intensive Technology

Virtualisation, Deployment, Orchestration & Monitoring

Domain experts shape their context

Research Developers shape contexts

Platform Developers enable common contexts

Data architects & workflow gurus

Information system engineers & Resource managers
DARE users create, use, refine and discard

- **Data**
  - **Data architects & workflow gurus**
  - **Information system engineers & Resource managers**

- **Methods**
  - **DARE API & Development kit**
  - **Research Developers**
  - **Platform Developers**
  - **enable common contexts**

- **Concepts**
  - **Others + DARE future: Tools & User interfaces**
  - **Domain experts shape their context**

- **Collections**
  - **DARE Platform**
  - **EOSC**
  - **Immediate priority**
  - **Long-term priority**
  - **Engineering priority**

**Priorities**
- **Immediate priority**
- **Long-term priority**
- **Scientific priority**
DARE users create, use, refine and discard

- **Others + DARE future: Tools & User interfaces**
- **DARE API & Development kit**
- **DARE Platform**
- **DARE Data-Intensive Technology**
- **Virtualisation, Deployment, Orchestration & Monitoring**

**Concepts**
- Long-term priority
- Scientific priority
- Immediate priority
- Engineering priority

**Methods**

**Data**

**Collections**

**Domain experts** shape their context

Research Developers

Data architects & workflow gurus

Information system engineers & Resource managers

EOSC

DARE hyper-platform: integration optimisation innovation conceptualisation
The three DARE technology pillars

- DARE Knowledge Base (DKB)
- Workflows as a Service (WaaS)
- Protected Pervasive Persistent Provenance (P4)

Researchers

Research developers

Production context
DKB-mediation

DARE Platform

DARE Knowledge Base

interface or tool

API

local files & DBs

local WaaS

kubernetes

dispel

Prov

External services

Deployed WaaS

Archival services

EUROPEAN OPEN SCIENCE CLOUD
DKB-mediation

User Action:
- interface or tool

DARE Platform
- DARE Knowledge Base
- API
- local files & DBs

External services
- Deployed WaaS

Internal services
- Archival services

19
DKB-mediation

User Action

1. interface or tool

2. Abstract request

DARE Platform

DARE Knowledge Base

API

local files & DBs

local WaaS

External services

Deployed WaaS

Archival services
DARE	Platform

DKB-mediation

User Action

1

interface or tool

2

Abstract request

API

DARE Platform

DARE Knowledge Base

Translation checked, detailed, completed & mapped to engineered implementation

19

Translated

Local files & DBs

Prov

External services

Deployed WaaS

Archival services

EUROPEAN OPEN SCIENCE CLOUD

COMMON WORKFLOW LANGUAGE

dispel4py

kubernetes

common workflow language
DKB-mediation

User Action
- interface or tool

1 Abstract request

DARE Platform
- DARE Knowledge Base

2

Translation
checked, detailed, completed & mapped to engineered implementation

3

Enactment
immediate actions

4

Local files & DBs

API

External services
- explicit detailed external deployments
- Deployed WaaS

Local WaaS
- kubernetes
- dispel

Prep & local work

Prov

Archival services
- European Open Science Cloud

WaaS
- common workflow language
DKB-mediation

User Action

1. interface or tool
2. Abstract request

DARE Platform

DARE Knowledge Base

Translation
checked, detailed, completed & mapped to engineered implementation

Enactment
immediate actions

API

local files & DBs

Prov

External services

Deployed WaaS

access data
store results

explicit detailed
external deployments
dynamic deployment
delegation

kubernetes

dispel4py

COMMON
WORKFLOW
LANGUAGE

Archival services

WaaS

local external deployments

prep & local work

access data
store results

EUROPEAN OPEN
SCIENCE CLOUD
DKB-mediation

User Action
1. Interface or tool
2. Abstract request

DARE Platform

DARE Knowledge Base

Translation
checked, detailed, completed & mapped to engineered implementation

Enactment
immediate actions

API

Local files & DBs

Local WaaS

Explicit detailed external deployments
Dynamic deployment delegation
Access data store results
Record prov

External services

Deployed WaaS

Dispel APY

European Open Science Cloud

Archival services

19
DKB-mediation

User Action

1. interface or tool
2. Abstract request

API

DARE Platform

DARE Knowledge Base

Translation
checked, detailed, completed & mapped to engineered implementation

Enactment
immediate actions

Steering

1. Visualised progress + diagnostics

local files & DBs

Prov

local WaaS

explicit detailed external deployments
dynamic deployment delegation

access data store results

External services

Deployed WaaS

Dispel

kubernetes

Common Workflow Language

Dynamic deployment delegation

record prov

record prov

European Open Science Cloud

Archival services
DKB-mediation

DARE Platform

DARE Knowledge Base

Translation
checked, detailed, completed & mapped to engineered implementation

Enactment

Steering

Finishing

User Action

1

2

Abstract request

Visualised progress + diagnostics

interface or tool

view of new state of user’s world

API

local files & DBs

local WaaS

Deployed WaaS

External services

Archival services

External services

view to new state of user’s world

checked, detailed, completed & mapped to engineered implementation
Provenance Tools

MVV - Monitoring and Validation

**Focussed analysis:** contextual monitoring, diagnostics and validation. Provides metadata and indication on the production of materialised data, dependency navigation, results management and discovery.

BDV — Bulk Dependencies Visualiser

**Comprehensive analysis:** user driven perspectives on single executions of scientific computations or involving many runs and users. It highlights resources and data exploitation patterns.
Provenance Tools

**MVV - Monitoring and Validation**

**Focussed analysis:** contextual monitoring, diagnostics, and validation.

- Provides metadata and indication on the production of materialised data, dependency navigation, results management, and discovery.

**BDV — Bulk Dependencies Visualiser**

**Comprehensive analysis:** user-driven perspectives on single executions of scientific computations or involving many runs and users. It highlights resources and data exploitation patterns, coping with scale, complexity, and duration.

**delivering repeatability**
Outline

• Vision and Goals
• Key insights
• Architecture
• Achievements and Work in Progress
Whole seismic example

Today
Whole seismic example

Today

- each step dispel4py linked using CWL
- seismologists interact via Jupyter notebooks
- targets chosen and encoded by IT experts
- optimisation & mapping fixed by IT experts

co-developed by seismologist, developers & IT experts
Whole seismic example

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Tomorrow

WSmesh
SSource
SeisSta
Interval

waveSim
SimTr
prepTrace
PSimTr

getTraces
ObsTr
prepTrace
PObsTr

compareGM
GMerr
mapGMerr

co-developed by seismologist, developers & IT experts
Whole seismic example

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‘Tomorrow’

- WSmesh
- SSource
- SeisSta
- Interval
- getTraces
- ObsTr
- prepTrace
- PSimTr
- compareGM
- GMerr
- mapGMerrs

Inputs & outputs described and checked

co-developed by seismologist, developers & IT experts
Whole seismic example

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‘Tomorrow’

‘Tomorrow’

- WSmesh
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- prepTrace
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- waveSim
- SimTr
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- compareGM
- GMerr
- mapGMerrs

User & system link stages with consistency checked

Inputs & outputs described and checked

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Whole seismic example

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‘Tomorrow’

User & system link stages with consistency checked

Inputs & outputs described and checked

waveSim

prepTrace

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compareGM

mapGMerrs
Whole seismic example

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‘Tomorrow’ target selection, deployment, mapping and orchestrated enactment

- waveSim
- prepTrace
- compareGM
- mapGMerrs
Whole seismic example

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‘Tomorrow’
- target selection, deployment, mapping and orchestrated enactment
Whole seismic example

Today
- each step: dispel4py linked using CWL
- seismologists interact via Jupyter notebooks
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'Tomorrow'
- target selection, deployment, mapping and orchestrated enactment

![Diagram of seismic example process](image)
Today

- each step dispel4py linked using CWL
- seismologists interact via Jupyter notebooks
- targets chosen and encoded by IT experts
- optimisation & mapping fixed by IT experts

'Tomorrow'

- target selection, deployment, mapping and orchestrated enactment
- target matching

co-developed by seismologist, developers & IT experts
Whole seismic example

Today
- each step dispel4py linked using CWL
- seismologists interact via Jupyter notebooks
- targets chosen and encoded by IT experts
- optimisation & mapping *fixed* by IT experts

Co-developed by seismologist, developers & IT experts

‘Tomorrow’
- target selection, deployment, mapping and orchestrated enactment
- target matching target choice

- waveSim
- getTraces
- prepTrace
- compareGM
- mapGMerrs

Rapid Ground Motion Assessment (RA)

Choose/upload seismic wavespeed & mesh

Choose/upload seismic source (point or fault)

Get pre-processed synth and data

Gather observed data

Run waveform simulation

Get ground motion parameters

Compare/integrate synthetic and observed ground motion data

Store data, metadata, provenance

EUROPEAN OPEN SCIENCE CLOUD
Whole seismic example

Today
- each step dispel4py linked using CWL
- seismologists interact via Jupyter notebooks
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co-developed by seismologist, developers & IT experts

‘Tomorrow’
- target selection, deployment, mapping and orchestrated enactment
- target matching, target choice, target preparation

Distributed Connected Software Deployments

SCIENCE CLOUD
Whole seismic example

Today
- each step
dispel4py linked using CWL
- seismologists interact via Jupyter notebooks
- targets chosen and encoded by IT experts
- optimisation & mapping fixed by IT experts

co-developed by seismologist, developers & IT experts

‘Tomorrow’
- target selection, deployment, mapping and orchestrated enactment
- target matching target choice target preparation map to targets

Diagram:
- waveSim
- getTraces
- prepTrace
- compareGM
- mapGMerrs
- CompFacs
- Distributed Connected Software Deployments
Seismic example summary

- waveSim
- getTraces
- prepTrace
- compareGM
- mapGMerrs
Seismic example summary

Key:
- concept & representation input/output
- validated data flow
- linking an entity with a descriptive concept
- the target could enact the action
- action optimised and mapped to target
- a distributed deployment of services and software stacks

Diagram:
- waveSim
- prepTrace
- compareGM
- mapGMerrs

Linking:
- choose/uploaded seismic source and velocity
- run waveform simulation
- gather observed data
- compare GM
- map GM errors

Rapid Ground Motion Assessment (RA)
- get pre-processed synth and data
- get ground motion parameters
- compare/integrate synthetic and observed ground motion data
- store data, metadata, provenance

Software Deployments:
- distributed configuration
- a distributed deployment of services and software stacks
Summary to take home
Summary to take home

• Growth unlimited and sustained
  • Data
  • Computation
  • Complexity

Simultaneously addressed for seismology and climate science

DARE

driving cognition and productivity

Extreme data
analytics, streaming, compression

Extreme complexity
abstraction, reproducibility, communication

Extreme computing
targeted optimisation, reflection, intelligence
Summary to take home

- Growth unlimited and sustained
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  - Computation
  - Complexity
- Challenges demanding and urgent

Simultaneously addressed for seismology and climate science

Innovation and access to new capabilities via sustainable framework bridging from concepts to resources
Summary to take home

- Growth unlimited and sustained
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  - Complexity
- Challenges demanding and urgent
- Conserving scarce resources
  - Human intellectual effort
  - Willingness to collaborate
  - Energy / GHG emissions
Summary to take home

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  • Energy / GHG emissions

Simultaneously addressed for seismology and climate science

DARE advances:
new API for developers
dispel4py + CWL workflows
SPECSEM3D on demand
Jupyter notebook sessions
Pervasive provenance + tools
imminent: conceptualisation

Innovation and access to new capabilities via sustainable framework bridging from concepts to resources
Delivered via the CMDC quartet, work contexts, provenance-driven tools and optimisation
Thank you

Questions?


https://drive.google.com/open?id=1JT6RdaFV0pTQ8aWx-8LY8etXlvd5mRag.

project-dare.eu
Thank you

Questions?


project-dare.eu
Part seismic example
Part seismic example

Today
- choose set of seismic stations
- retrieve traces into local dir 1
- prep or reject in local dir 2
- start time & duration
- prep parameters

user-driven actions forming collections in directories
Part seismic example

User-driven consistency

Localised actions

Redundant data movement

Re-evaluate not re-use

Choose set of seismic stations

Retrieve traces into local dir 1

Process or reject in local dir 2

Prepare parameters

User-driven consistency

Localised actions

Redundant data movement

Re-evaluate not re-use

Rapid Ground Motion Assessment (RA)

Get pre-processed synth and data

Get ground motion parameters

Compare/integrate synthetic and observed ground motion data

Store data, metadata, provenance
Part seismic example

Today

- Choose set of seismic stations
- Retrieve traces into local dir 1
- Prep or reject in local dir 2
- Prep parameters
- Start time & duration

‘Tomorrow’

```
wfcatalog { SeisSta }
```

```
setup in shared seismic work context
```

```
user chooses

seisStations = query wfcatalog for zone(event) union ourDeployment excluding untrusted
traces = tracePrep( seisStations.getTraces(event.start, event.duration+delta, qualCheck) )
```

co-developed by seismologist & developer
Part seismic example

‘Tomorrow’

\[ \text{wfcatalog} \{ \text{SeisSta} \} \quad \{ \text{setup in shared seismic work context} \} \]

\text{event} = ...

\text{user chooses}

\text{seisStations} = \text{query} \text{ wfcatalog for zone(event) union} \text{ ourDeployment excluding untrusted} \text{ traces} = \text{tracePrep( seisStations.getTraces(event.start, event.duration+delta, qualCheck) )}
Part seismic example

\[
\text{setup in shared seismic work context}
\]

\[
\text{co-developed by seismologist & developer}
\]

DARE Dev. Kit makes it easy for developers to deliver to application experts in their preferred form
Part seismic example

‘Tomorrow’

\[
\text{setup in shared seismic work context}
\]

user chooses

\[
\text{seisStations} = \text{query wfcatalog for zone(event)} \cup \text{ourDeployment excluding untrusted}
\]

\[
\text{traces} = \text{tracePrep( seisStations, getTraces(event.start, event.duration + \delta, qualCheck) )}
\]

DARE Dev. Kit makes it easy for developers to deliver to application experts in their preferred form

All terms consistently and correctly interpreted via the DKB

co-developed by seismologist & developer
Part seismic example

DARE Dev. Kit makes it easy for developers to deliver to application experts in their preferred form

All terms consistently and correctly interpreted via the DKB

user chooses

seisStations = query wfcatalog for zone(event) union ourDeployment excluding untrusted

traces = tracePrep( seisStations.getTraces(event.start, event.duration+delta, qualCheck) )

‘Tomorrow’

setup in shared seismic work context

lazy evaluation potential

co-developed by seismologist & developer
Part seismic example

Treating seismic events:

User chooses:

```
seisStations = query wfcatalog for zone(event) union ourDeployment excluding untrusted
traces = tracePrep( seisStations.getTraces(event.start, event.duration+delta, qualCheck) )
```

DARE Dev. Kit makes it easy for developers to deliver to application experts in their preferred form.

All terms consistently and correctly interpreted via the DKB.

Lazy evaluation potential:

setup in shared seismic work context

co-developed by seismologist & developer
**Part seismic example**

DARE Dev. Kit makes it easy for developers to deliver to application experts in their preferred form.

All terms consistently and correctly interpreted via the DKB.

Event setup in shared seismic work context

Lazy evaluation potential

co-developed by seismologist & developer

---

\[
\text{seisStations} = \text{query wfcatalog for Zone(event) union ourDeployment excluding untrusted}
\]

\[
\text{traces} = \text{tracePrep(seisStations.getTraces(event.start, event.duration+delta, qualCheck))}
\]
DKB-mediated action
DKB-mediated action

• Concepts researchers require
  • tailored views
  • controlled incremental development
  • controlled sharing
  • detail only when wanted
  • trustworthy persistent interpretation
DKB-mediated action

• Concepts researchers require
  • tailored views
  • controlled incremental development
  • controlled sharing
  • detail only when wanted
  • trustworthy persistent interpretation

• e-Infrastructure Concepts engineers require
  • bridge researchers’ worlds to engineering
  • common sustainable framework
  • to tailor and automatically populate views
  • controlled incremental development
  • managed releases
  • visual steered grouped summaries
  • affordable optimised interpretation
DKB-mediated action

- Concepts researchers require
  - tailored views
  - controlled incremental development
  - controlled sharing
  - detail only when wanted
  - trustworthy persistent interpretation
- e-Infrastructure Concepts engineers require
  - bridge researchers’ worlds to engineering
  - common sustainable framework
  - to tailor and automatically populate views
  - controlled incremental development
  - managed releases
  - visual steered grouped summaries
  - affordable optimised interpretation
DKB-mediated action

- Concepts *researchers* require
  - tailored views
  - controlled incremental development
  - controlled sharing
  - detail only when wanted
  - trustworthy persistent interpretation
- e-Infrastructure Concepts *engineers* require
  - bridge researchers’ worlds to engineering
  - common sustainable framework
  - to tailor and automatically populate views
  - controlled incremental development
  - managed releases
  - visual steered grouped summaries
  - affordable optimised interpretation
DKB-mediated action

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DARE Knowledge Base

- Time-stamped sequence of entries
- Local tokens for external entities
DKB-mediated action

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DARE Knowledge Base

- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
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**DARE Knowledge Base**
- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
- Concepts, Methods, Data and *Collections*
DKB-mediated action

• Concepts *researchers* require
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DARE Knowledge Base

- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
- Concepts, Methods, Data and *Collections*
- Dynamic populations: create, update, use, discard
DKB-mediated action

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**DARE Knowledge Base**

- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
- Concepts, Methods, Data and *Collections*
- Dynamic populations: create, update, use, discard
- Virtual: local control external action + DKB delta
DKB-mediated action

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  - tailored views
  - controlled incremental development
  - controlled sharing
  - detail only when wanted
  - trustworthy persistent interpretation
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### DARE Knowledge Base

- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
- Concepts, Methods, Data and *Collections*
- Dynamic populations: create, update, use, discard
- Virtual: local control external action + DKB delta
- Tailoring: import (view of) context, import & align bundles + new entities
DKB-mediated action

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  • tailored views
  • controlled incremental development
  • controlled sharing
  • detail only when wanted
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DARE Knowledge Base

- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
- Concepts, Methods, Data and Collections
- Dynamic populations: create, update, use, discard
- Virtual: local control external action + DKB delta
- Tailoring: import (view of) context, import & align bundles + new entities
- Innovation: local + promotion or branch & import of releases
DKB-mediated action

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**DARE Knowledge Base**

- Time-stamped sequence of entries
- Local tokens for external entities
- Local representations for internal entities
- Concepts, Methods, Data and Collections
- Dynamic populations: create, update, use, discard
- Virtual: local control external action + DKB delta
- Tailoring: import (view of) context, import & align bundles + new entities
- Innovation: local + promotion or branch & import of releases
- One DKB per DARE platform deployment updated platform core releases