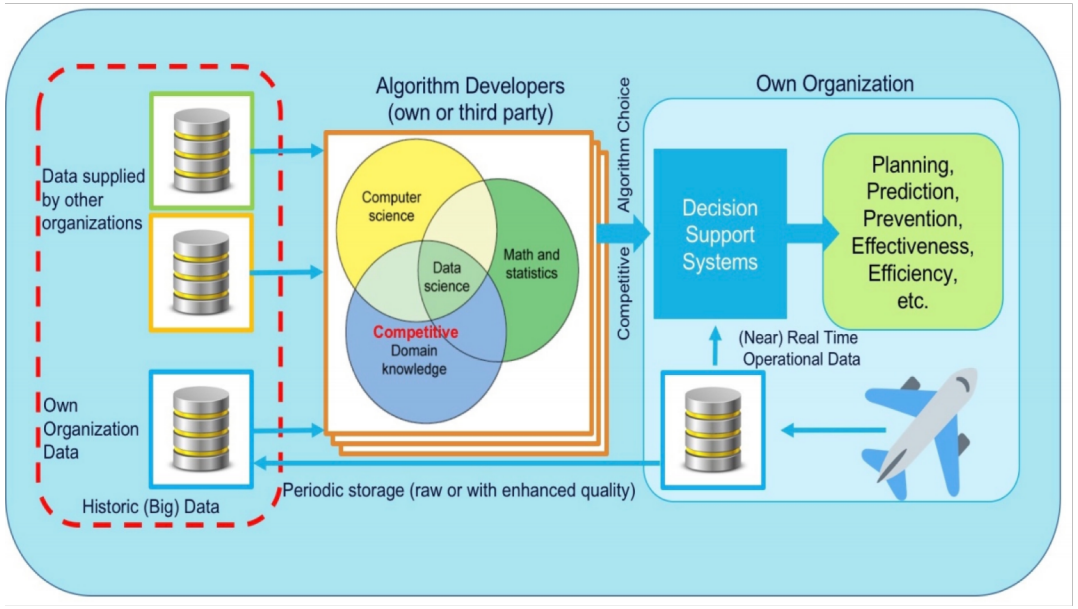
Modeling of Collaborations in Digital Marketplaces

Lu Zhang
Systems and Networking Lab
University of Amsterdam

This project has received funding from the European Union's Horizon 2020 research and innovcation programme under grant agreement No 769288

The more data, the better: aircraft maintenance

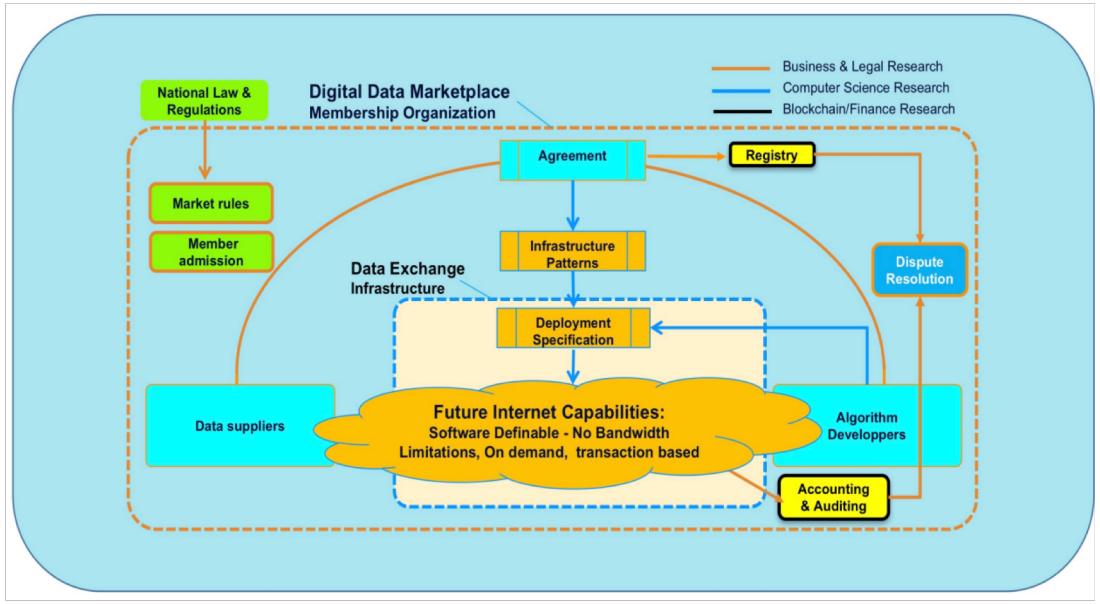
- Predict need for aircraft maintenance with AI/ML algorithms
- Better aircraft data availability contributes to more reliable result
- How can AL/ML algorithm developers access aircraft data from multiple competing Airline companies?



Digital Marketplace (DMP)

- Apply Digital Marketplace concepts to facilitate trustworthy data sharing for a particular purpose

- A **Digital Marketplace** is a membership organization supporting a common goal
  - e.g. enable data sharing to increase value and competitiveness of AI/ML algorithms

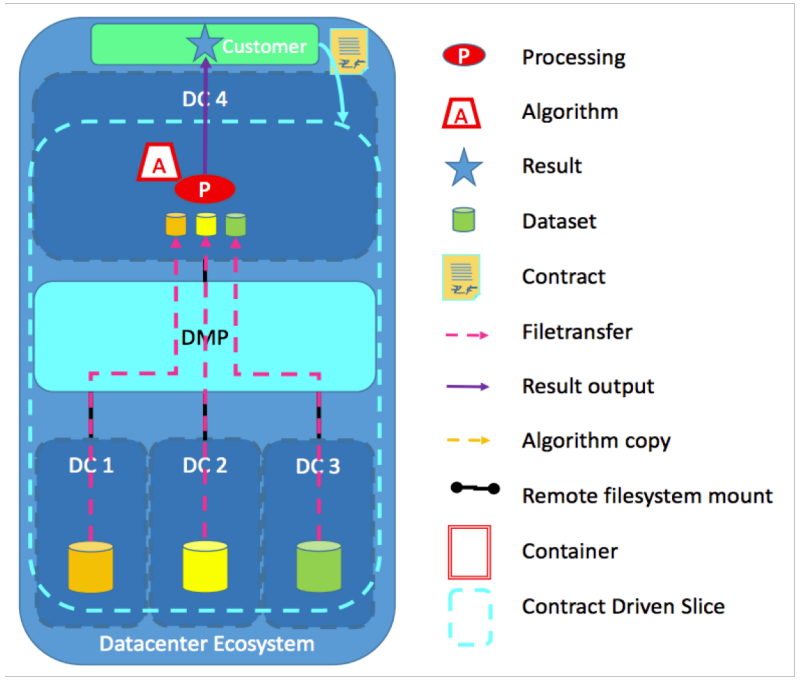


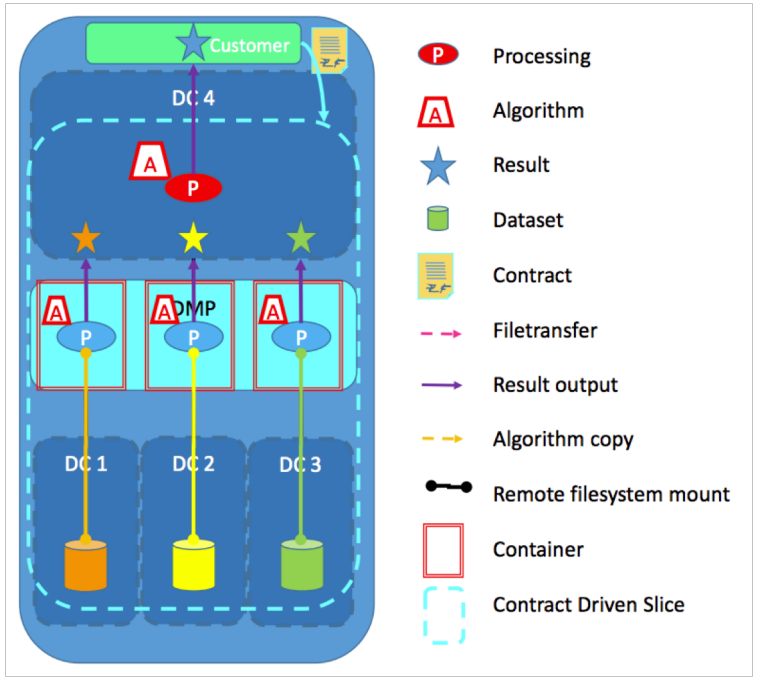
Collaboration Models

- Market members arrange **digital agreements** to exchange data and compute for a particular purpose under specific conditions

- **Collaboration models**
  - Describe the rules of how data and compute are shared, accessed and used based on digital agreements
  - Terminologies:
    - Digital Data Marketplace → Collaboration Archetypes
    - Potential Customer → Application Request

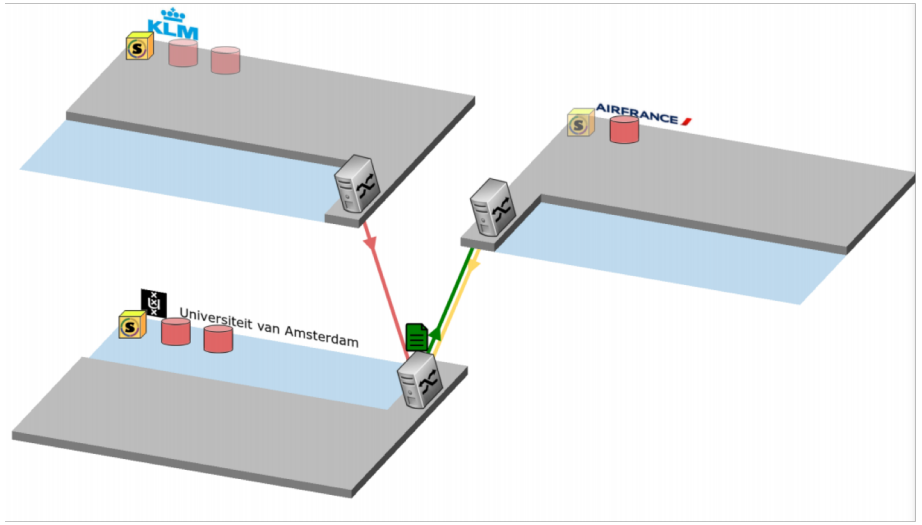
Collaboration Archetypes



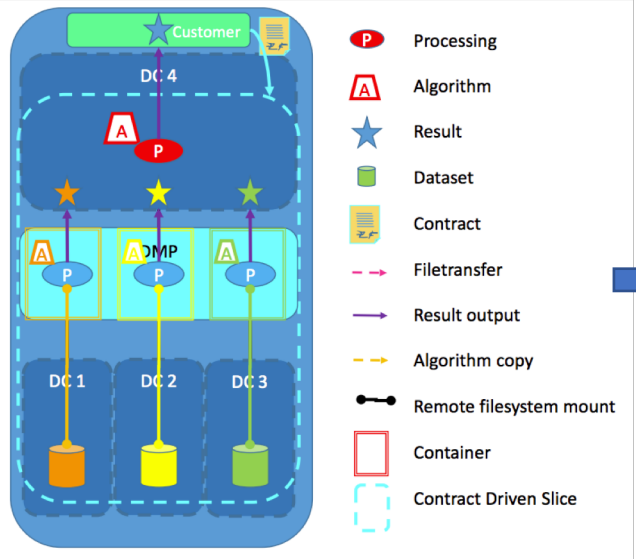


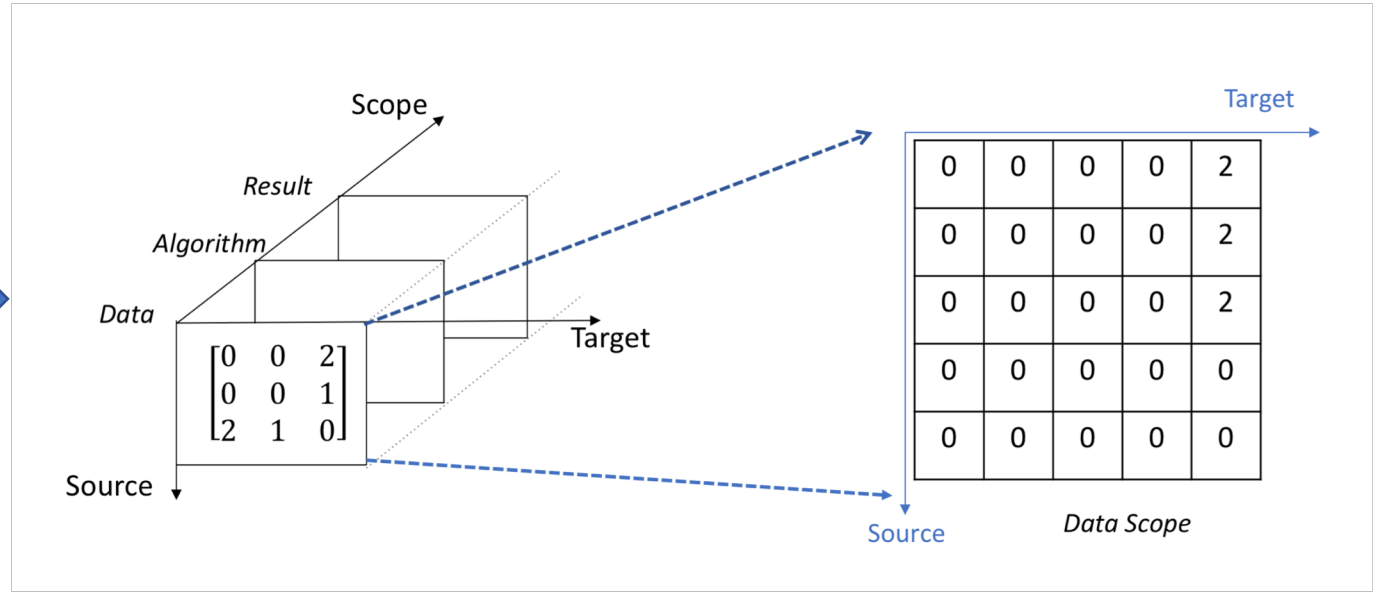
Application Request

- Collaborating computing on 3 distributed data harbors
  - KLM and Air France do not trust each and employ a trusted 3rd party to send data and compute for processing
- Hard/ Soft Requests
  - Hard → non-negotiable and must be fulfilled
  - Soft → Adjustable to better fit any existing archetype



How to formalize multi-party collaborations generically?

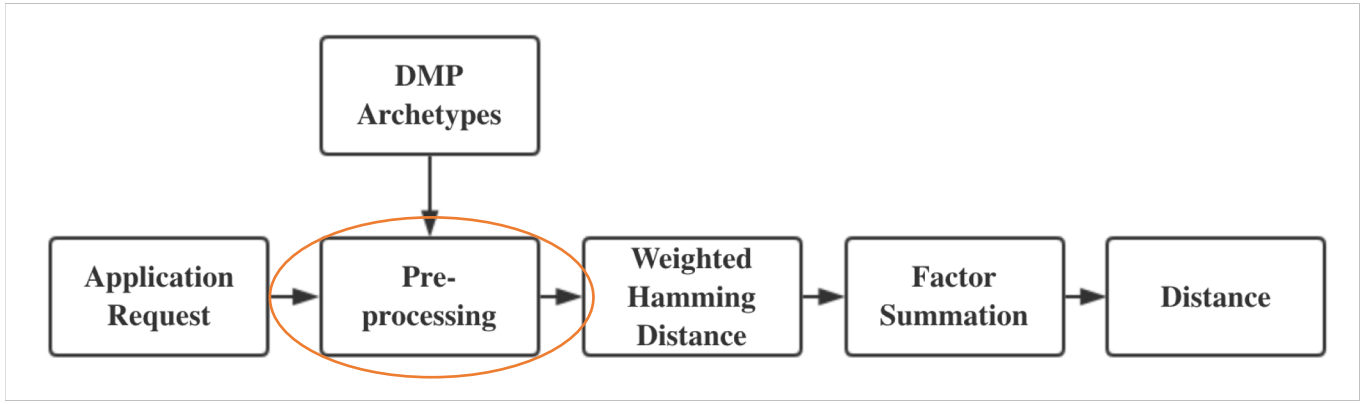




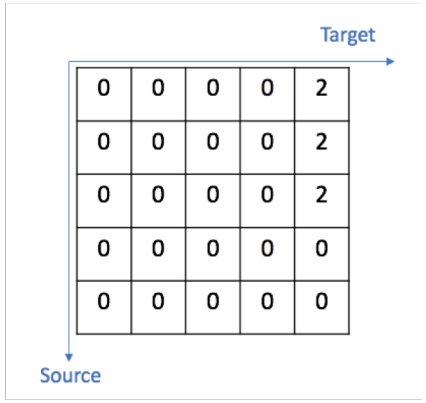
- Parties in the DDM may collaborate across a number of *scopes*: ***data, algorithm and result***
- In each scope, a number, which we call ***collaboration level***, describes the concrete approach of asset sharing between any source and target
  - E.g. Filetransfer or Remote filesystem mount
- This model is ***generic***, more scopes and collaboration levels could be extended

How to match application requests to collaboration archetypes?

- Map any collaboration model as a point in discrete space – relative distance
  - Currently adopted distance calculation method

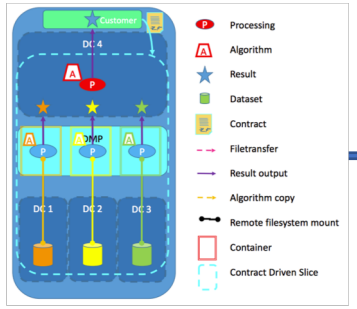


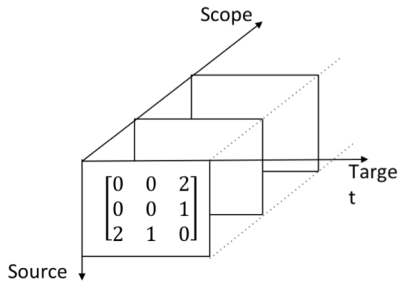
  - Pre-processing block for more commensurate comparison
    - Reduce the influence of how we assign those participating parties in the matrices
    - Aim to find an optimum fitness between two collaboration models

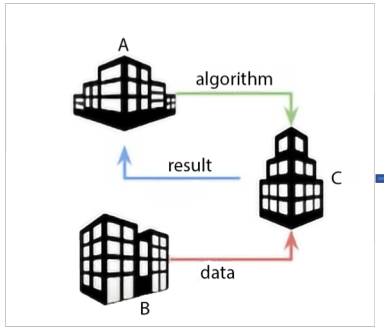


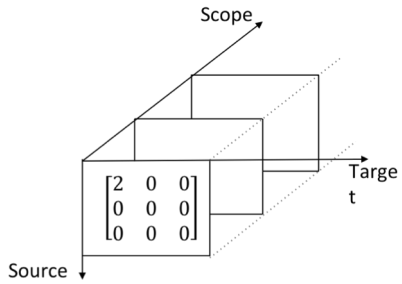
- The *closeness* of application request and the supported collaboration archetypes can be identified

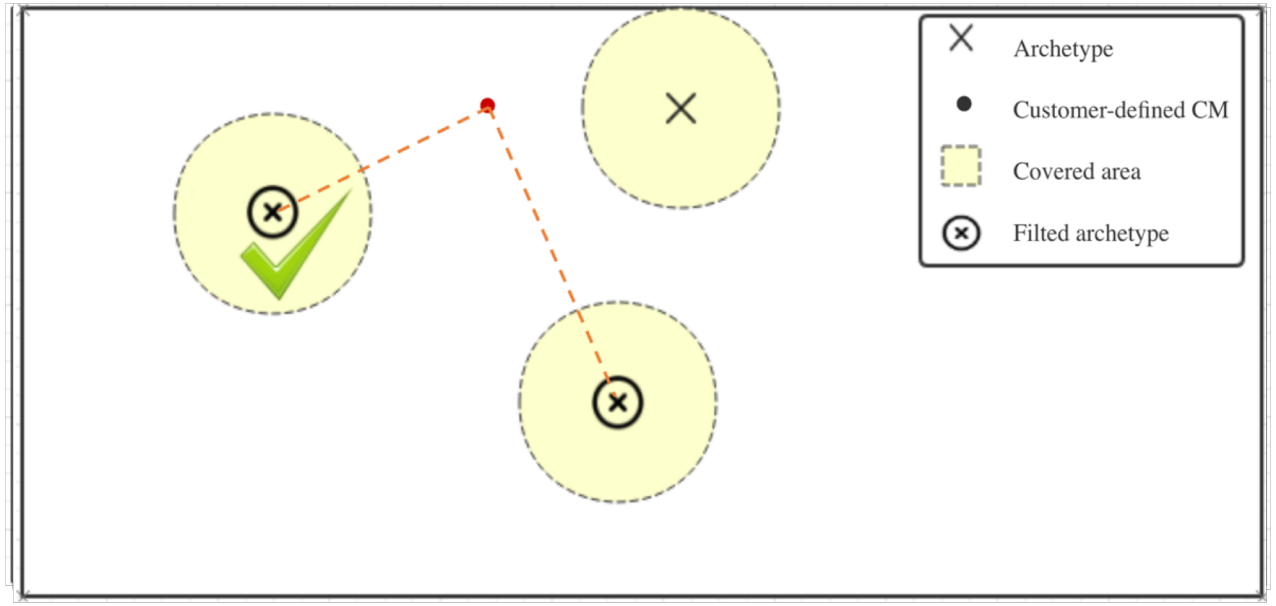
How to match application requests to DMP archetypes?





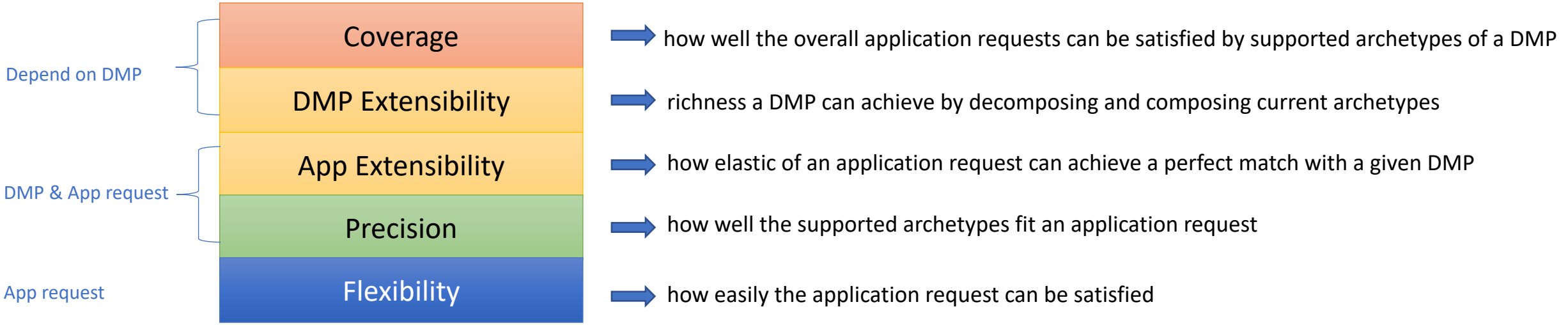






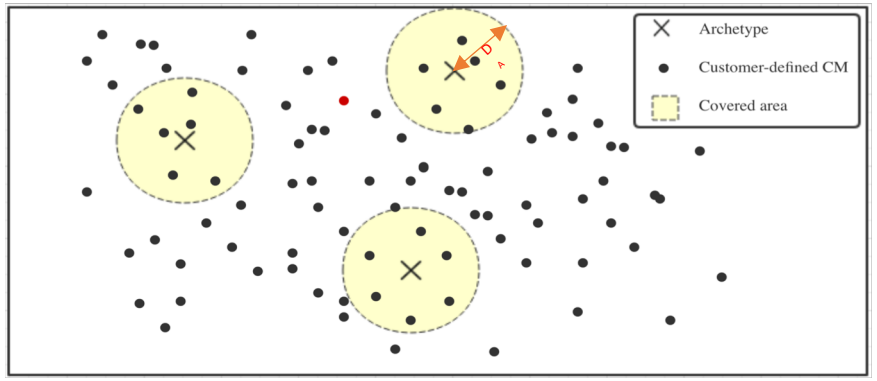
Evaluation metrics of a DMP

- Motivation:
  - Provide a-priori information for DMP providers and potential customers
  - Allow for comparison and intelligent selection of competing DMPs
- Evaluation metrics



How to quantize? --Coverage

- A higher *coverage is* achieved by lowering customer satisfaction degree
  - Pre-define a tolerant distance D_A
  - Covered area of each archetype is modeled effectively as a sphere with radius D_A
  - Total covered area is the union of individual covered area



- An optimization algorithm for coverage calculation is designed for complexity reduction

How to use the proposed metrics for intelligent selection?

- Each DMP may support multiple collaboration archetypes
- Compute metrics with a specific application request
- Select the optimal DMP – perfect match by minimum modification effort

Algorithm 2 Metrics validation with a specific collaboration request

```
Input collaboration request → cr
Sort DMP candidates on coverage in descending order → DMP_rank
for dmp_i ∈ DMP_rank do
    if precision(dmp_i, cr) = 1 then
        dmp_i → dmp_opt
        go to output
    end if
end for
if flexibility(cr) > 0 then
    if ∃E_A ≥ 0 then
        Select dmp_i with maximum E_A
        dmp_i → dmp_opt
        go to output
    end if
end if
Extend DMP_rank by primitive composition → DMP_e
for dmp_i ∈ DMP_e do
    if precision(dmp_i, cr) = 1 then
        dmp_i → dmp_opt
        go to output
    end if
end for
output:
Return dmp_opt
```

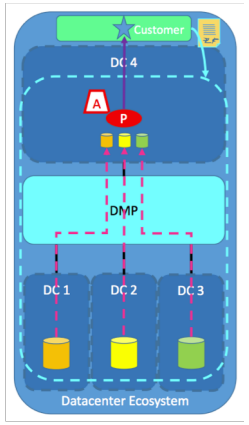
Precision → Exact match

Flexibility → Possibility to extend application request

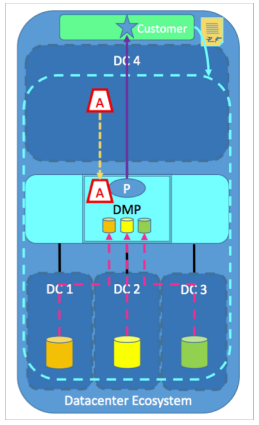
App Extensibility → Exact match by extending application request

DMP Extensibility → Exact match by archetype recombination

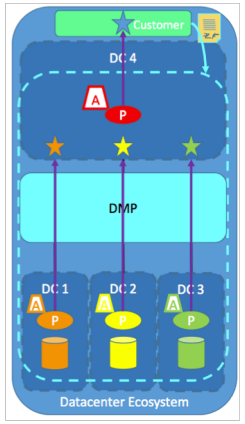
Collaboration archetypes in project DL4LD



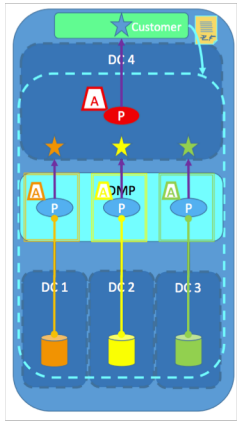
Archetype I



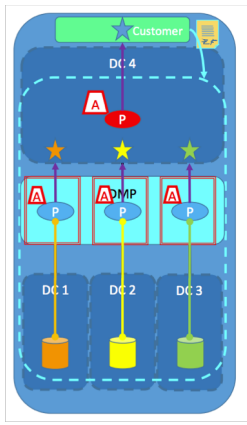
Archetype II



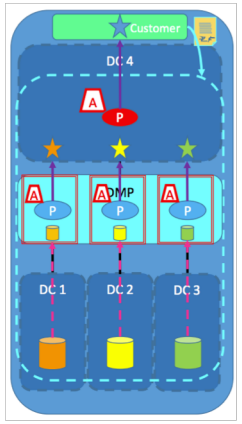
Archetype III



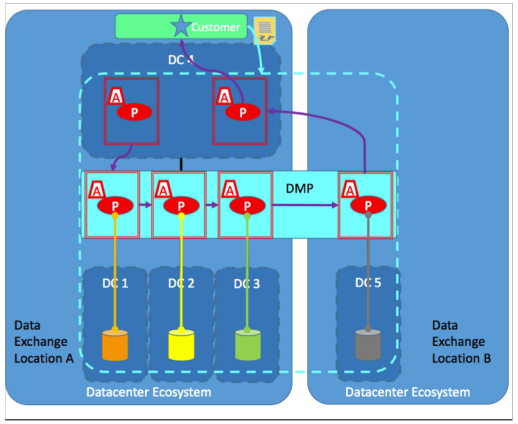
Archetype IV



Archetype V

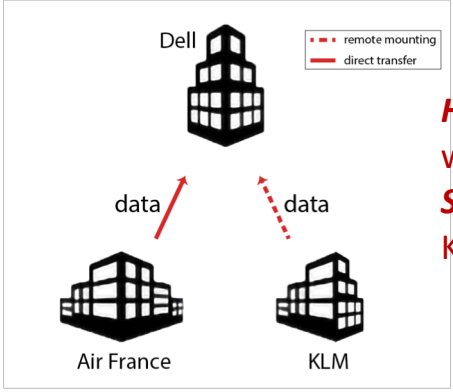


Archetype VI



Archetype VII

Intelligent selection of DMPs



Hard Requests: Air France and KLM trust Dell and are willing to send their data

Soft Requests: Air France prefers direct data transfer and KLM prefers remote mounting

DMP	Supported Archetype Trust Models
DMP_1	{1, 2, 3, 4, 7}
DMP_2	{1, 2, 3, 5, 7}
DMP_3	{1, 2, 3, 5, 6}
DMP_4	{1, 3, 4, 5, 7}
DMP_5	{2, 3, 4, 6, 7}

	DMP_1	DMP_2	DMP_3	DMP_4	DMP_5
Coverage (1e−12)	4.29	4.28	4.26	3.69	3.65
Precision	0.83	0.83	0.83	0.83	-0.67
Flexibility	0.06	0.06	0.06	0.06	0.06
Application extensibility	0.5	0.5	0.5	0.5	$-\infty$

DMP_1 wins for the specific application request!

Conclusions

- Formalize multi-party collaborations into mathematical representations
- Ability to match and identify closeness between any application request and collaboration archetypes
  - Map archetypes and application requests together into a discrete space
- Define multiple generic metrics for DMP evaluation
  - Demonstrate effectiveness of metrics with DL4LD use case
  - Intelligent selection of DMP candidates

Future work

- Further improve multi-party collaboration modeling methodology
  - Enrich defined scopes and collaboration levels, e.g. locations information, hardware resource
  - Applicable for more concrete and complex use case
  - Include cost into the model
- Multi-criteria decision making by incorporating security perspective
- Manage to detect the concrete blocks in the archetype that produce the mismatch
  - Working toward a zero distance

Thank You & Any Questions?

https://www.dl4ld.net/

https://www.dl4ld.nl/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769288