Modeling of Collaborations in Digital Marketplaces

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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
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?

Filtering: Only consider collaboration archetypes that fully satisfy the hard requests.
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

- **Coverage**: how well the overall application requests can be satisfied by supported archetypes of a DMP
- **DMP Extensibility**: richness a DMP can achieve by decomposing and composing current archetypes
- **App Extensibility**: how elastic of an application request can achieve a perfect match with a given DMP
- **Precision**: how well the supported archetypes fit an application request
- **Flexibility**: how easily the application request can be satisfied
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

**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

<table>
<thead>
<tr>
<th>DMP</th>
<th>Supported Archetype Trust Models</th>
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<tbody>
<tr>
<td>DMP(_1)</td>
<td>{1, 2, 3, 4, 7}</td>
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<tr>
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<td>{1, 2, 3, 5, 7}</td>
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<tr>
<td>DMP(_5)</td>
<td>{2, 3, 4, 6, 7}</td>
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<tr>
<th></th>
<th>DMP(_1)</th>
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<th>DMP(_3)</th>
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<tbody>
<tr>
<td>Coverage (1e−12)</td>
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</tr>
<tr>
<td>Application extensibility</td>
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<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>$-\infty$</td>
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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/
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