A Graph Engine Service for Cloud AI Platforms

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Trend of AI

#AIFears?

Artificial Intelligence poses an existential threat to humanity

Regulation is necessary to prevent unintended consequences

Link threshold 22 of 33
Reinvented Wheels in Parallel Universe?
Sir Berners-Lee believes the core value of RDF semantic web is to transform WWW into media for information exchange.

**Semantic Web**

### RDF Graph

A collection of triples, linking the description of resources

<table>
<thead>
<tr>
<th>subject</th>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yinglong</td>
<td>work_in</td>
<td>Futurewei</td>
</tr>
<tr>
<td>Yinglong</td>
<td>born</td>
<td>1980</td>
</tr>
<tr>
<td>Futurewei</td>
<td>has_HQ</td>
<td>Shenzhen</td>
</tr>
</tbody>
</table>

**Example:**

- **Yinglong** (subject) work_in (predicate) **Futurewei** (object)
- **Yinglong** (subject) born (predicate) 1980 (object)
- **Futurewei** (subject) has_HQ (predicate) Shenzhen (object)
Labeled Property Graph

- Property graph is a data representation model with strong expressiveness.
- Property graph is supported by most graph databases (NoSQL) and also forms the foundation of graph analysis.

- Vertices
  - Unique ID for each
  - A set of (directed) edges
  - Property: a set of key-value pairs

- Edges
  - Unique ID for each
  - Two end vertices
  - With at least a label
  - Property: a set of key-value pairs
Heterogeneous Information Network

A Survey of Heterogeneous Information Network Analysis

Authors: Chuan Shi, Yitong Li, Jiawei Zhang, Yizhou Sun, Philip S. Yu

Published in: IEEE Transactions on Knowledge and Data Engineering
Volume 29 Issue 1, January 2017
Page 17-37
DOI: 10.1109/TKDE.2016.2588561

CONCEPT-RICH RECOMMENDATION: INTEGRATING LINKS, TEXT, AND SPATIO-TEMPORAL DIMENSIONS

August 11, 2017
Microsoft Satori knowledge graph utilizes Trinity and GraphDB.

GraKn.ai utilizes a property graph as its data layer.
Property Graph Storage

Eywa: Unified property graph analysis and query system

Labeled property graph model and its schema description

- 9 VMs from data center
- Each with 22-core CPU, 125 GB memory
- Orkut: |V|=3.07M, |E|=117M
- Friendster: |V|=65M, |E|=1.8B
- Kronecker: |V|=984M, |E|=106.5B
Graphical Models

• Observations
  - $X_{ewdv}$: whether extractor $e$ extracts from source $w$ the $(d,v)$ item-value pair

• Latent variables
  - $C_{wdv}$: whether source $w$ indeed provides $(d,v)$ pair
  - $V_d$: the correct value(s) for $d$

• Parameters
  - $A_w$: Accuracy of source $w$
  - $P_e$: Precision of extractor $e$
  - $R_e$: Recall of extractor $e$

Predict the correctness of extraction and accuracy

Example of GM

$P(G, S, R) = P(G \mid S, R) \cdot P(S \mid R) \cdot P(R)$

X. Dong et al., Knowledge-based trust: estimating the trustworthiness of web sources. In VLDB, 2015
Import properties/metrics:
- Small-world effect
- Betweenness
- Eccentricity/Centrality
- Transitivity
- Resilience
- Community structure
- Clustering coefficient
- Matching index

Complex network models:
- Poisson random graph
  - degree~Poisson
  - Small world effect
- Watts and Strogatz graph
  - Transitivity
  - Small world effect
- Barabasi and Albert graph
  - Small world
  - Power law

- Effectiveness of knowledge inference is upon the completeness and quality of the linked data
- Transitivity between two vertices may reveal redundant links or missing connections
- Clusters on instance graph helps manage knowledges efficiently
- Inconsistency can be identified through such analysis
Most embedding frameworks are inherently **transductive** and can only generate embeddings for a single fixed graph.

- These transductive approaches do not efficiently generalize to unseen nodes (e.g., in **evolving** graphs or **hidden** vertices)
- In contrast, GraphSAGE is an inductive framework that leverages node attribute information to efficiently generate representations.
Eywa - Integrated Graph Processing Platform
Improved Graph Data Organization

Observations on graph computing

- Y. Xia, et. al, C-Graph: A Highly Efficient Concurrent Graph Processing Framework, ICS, 2018
- Y. Xia, et. al, An Edge-Set Based Large Scale Graph Processing System, IEEE Big Data 2016

Reduce randomness in data access

Operation

(a) Execution interval (vertices 1-2)

(b) Execution interval (vertices 3-4)
Scheduler/Prefetch of Relaxed BSP

Flow direction

1 4 7 1 2 3 2 5 8 4 5 6

- load shard
- load PSW
- local computation
- queue updates
- send updates
- recv updates
- update/storePSW

- speedup due to overlapping

- load shard
- local computation
- queue updates
- update/storePSW
- send updates
- recv updates
- load PSW
- preload next shared

partially included due to preloading

task type: disk IO, CPU, network IO

Dash box includes all tasks within an iteration
Experiments

Eywa VS. Titan ($|V|: 3072441, |E|: 117185083$)

- Eywa outperformed the baseline method
- Eywa shows consistent running time
Experiments - 3

- **Consistent** performance observed across graphs of different scales
Demo

Demo - 2
Thanks

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