The case against specialized graph engines

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Motivation

- Graph analytics is now common
- Response = new specialized graph engines

"One Size Fits All": An Idea Whose Time Has Come and Gone

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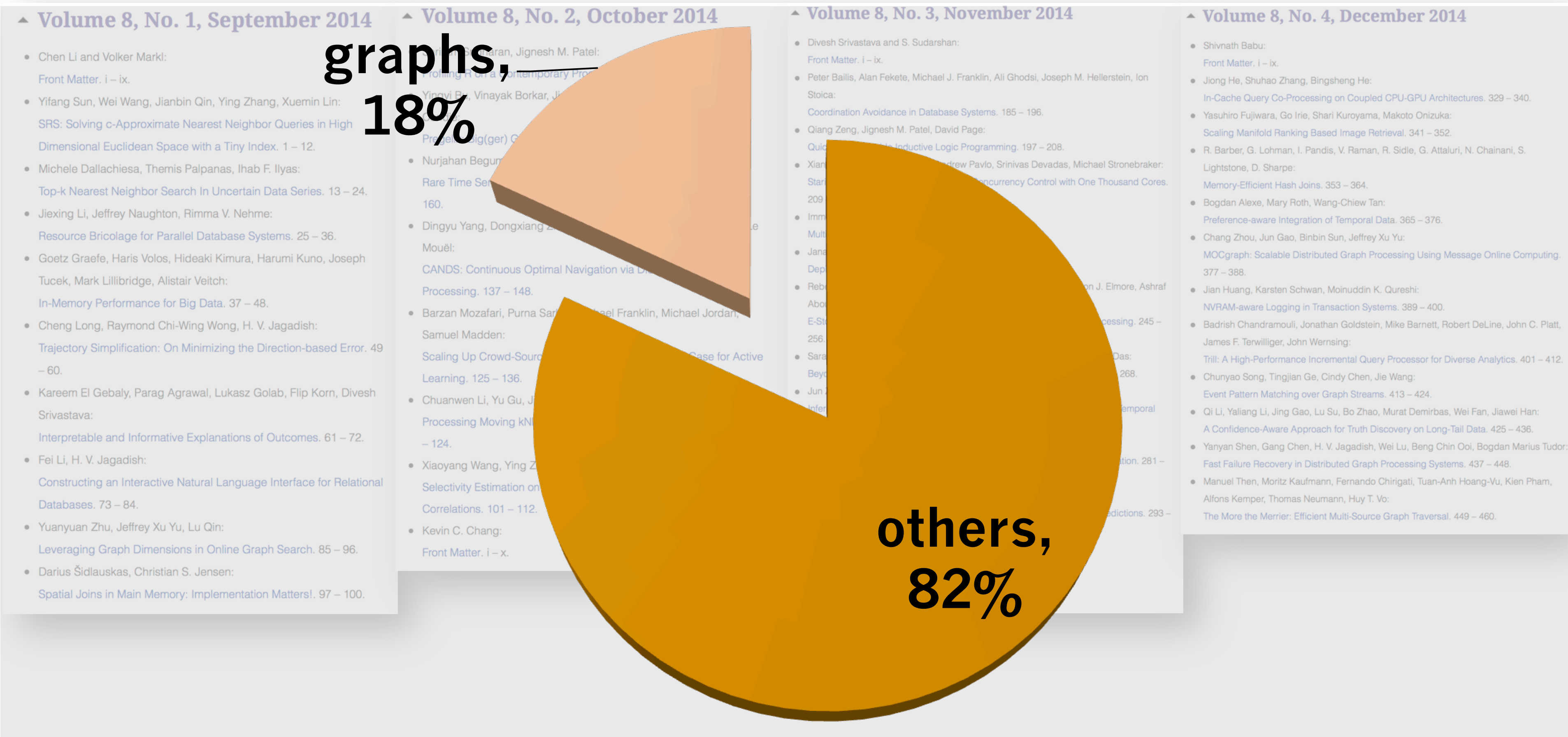

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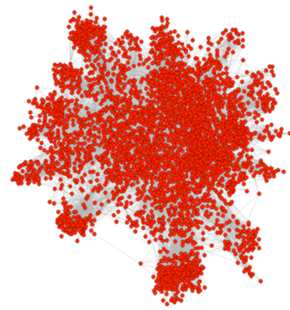
Google Pregel

APACHE GIRAPH



Stanford GPS

GraphLab Unleash Data Science™

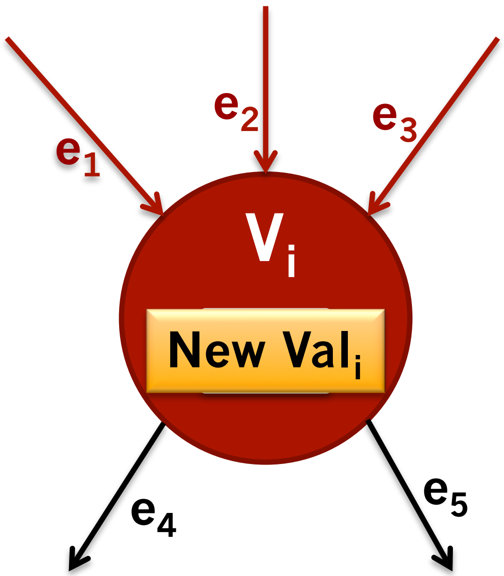
Question: Is graph processing that different from other types of data processing?

Our Answer: No. Can be subsumed by "traditional" relational processing

What is appealing about these new engines?

Vertex-centric API → Easy to write graph programs → Higher programmer productivity

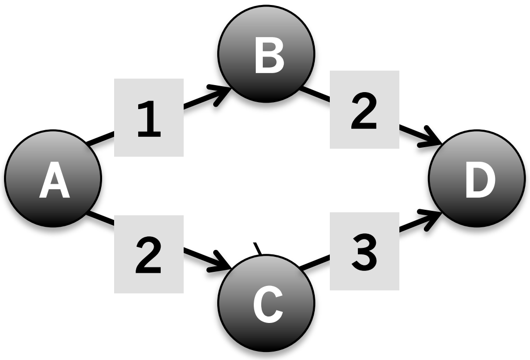
Graph API: Giraph



Vertex Centric:

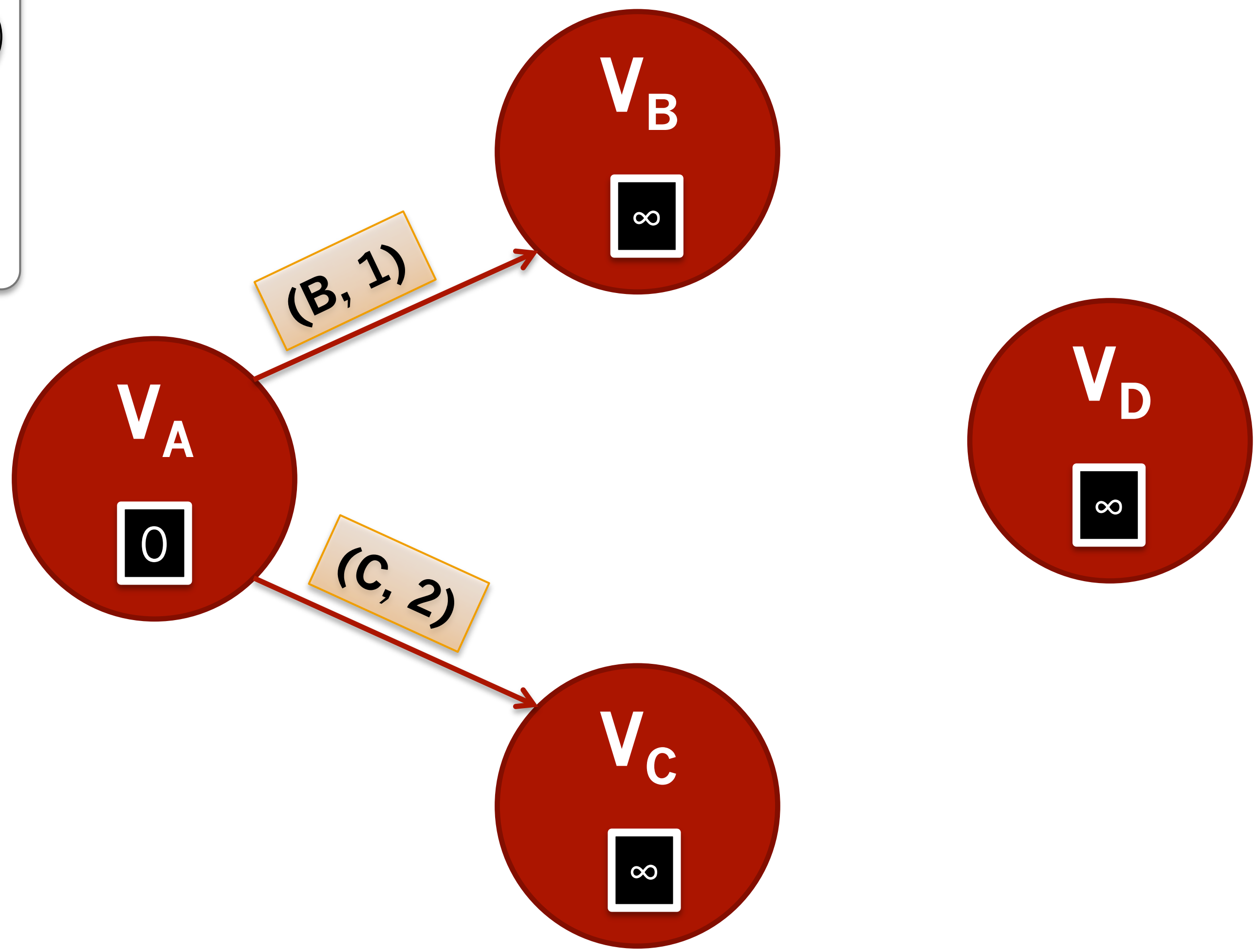
```
do {
  foreach vertex in the graph {
    receive_messages();
    mutate_vertex_value();
    if (send_to_neighbors()) {
       send_messages_to_neighbors();
    }
  }
} until (has_converged() || reached_limit())
```

Example: Shortest path



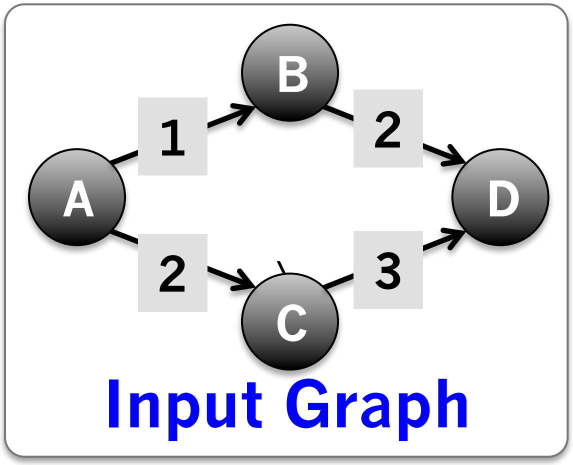
Input Graph

Computation & Communication Pattern

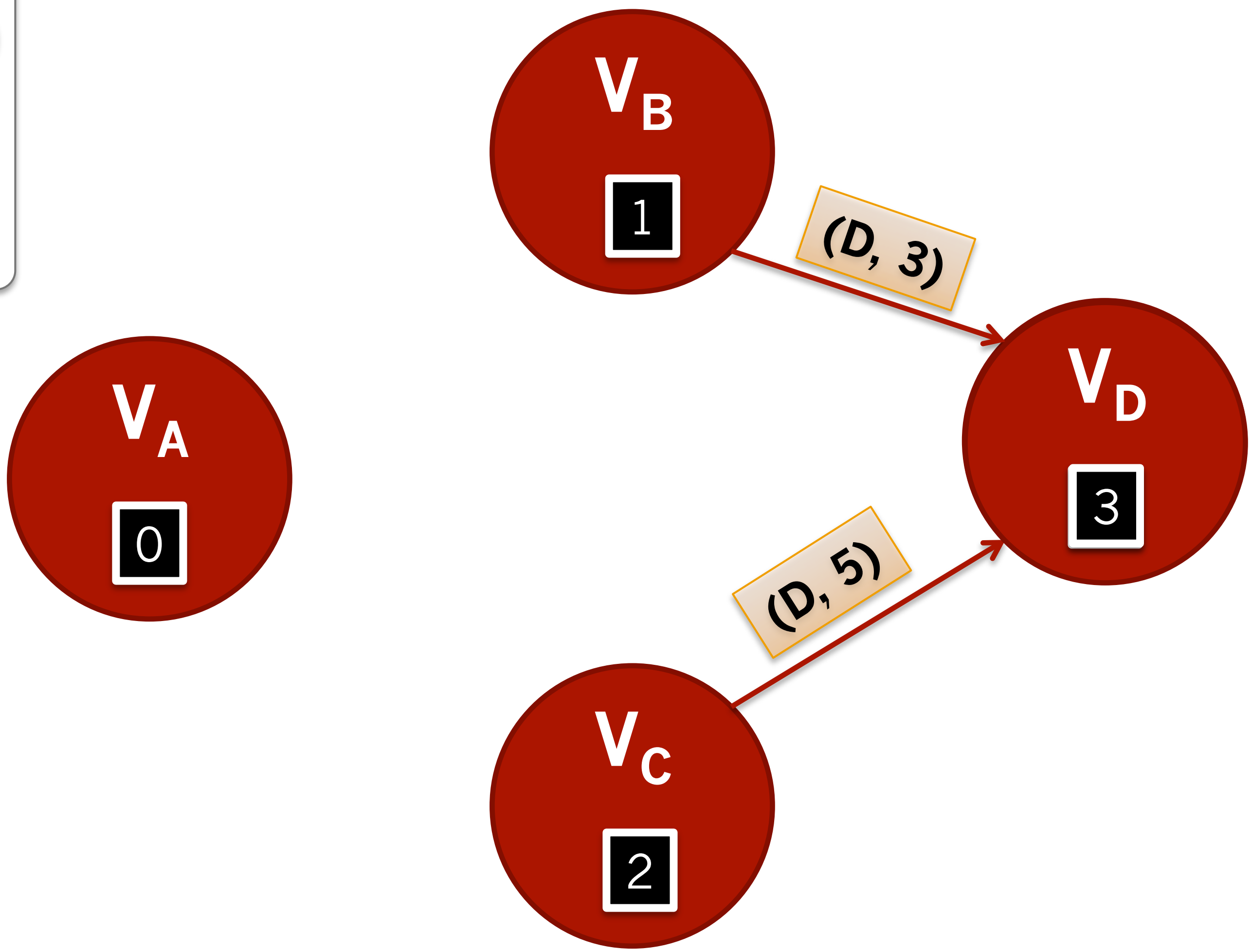


Iteration 1

Example: Shortest path

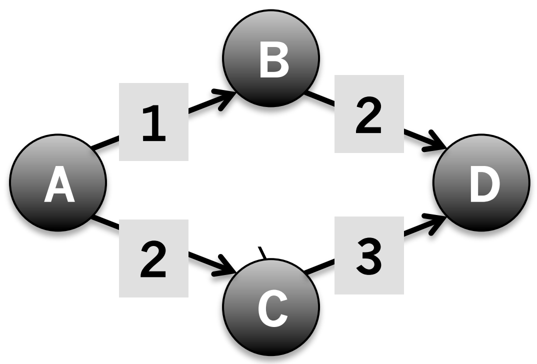


Computation & Communication Pattern



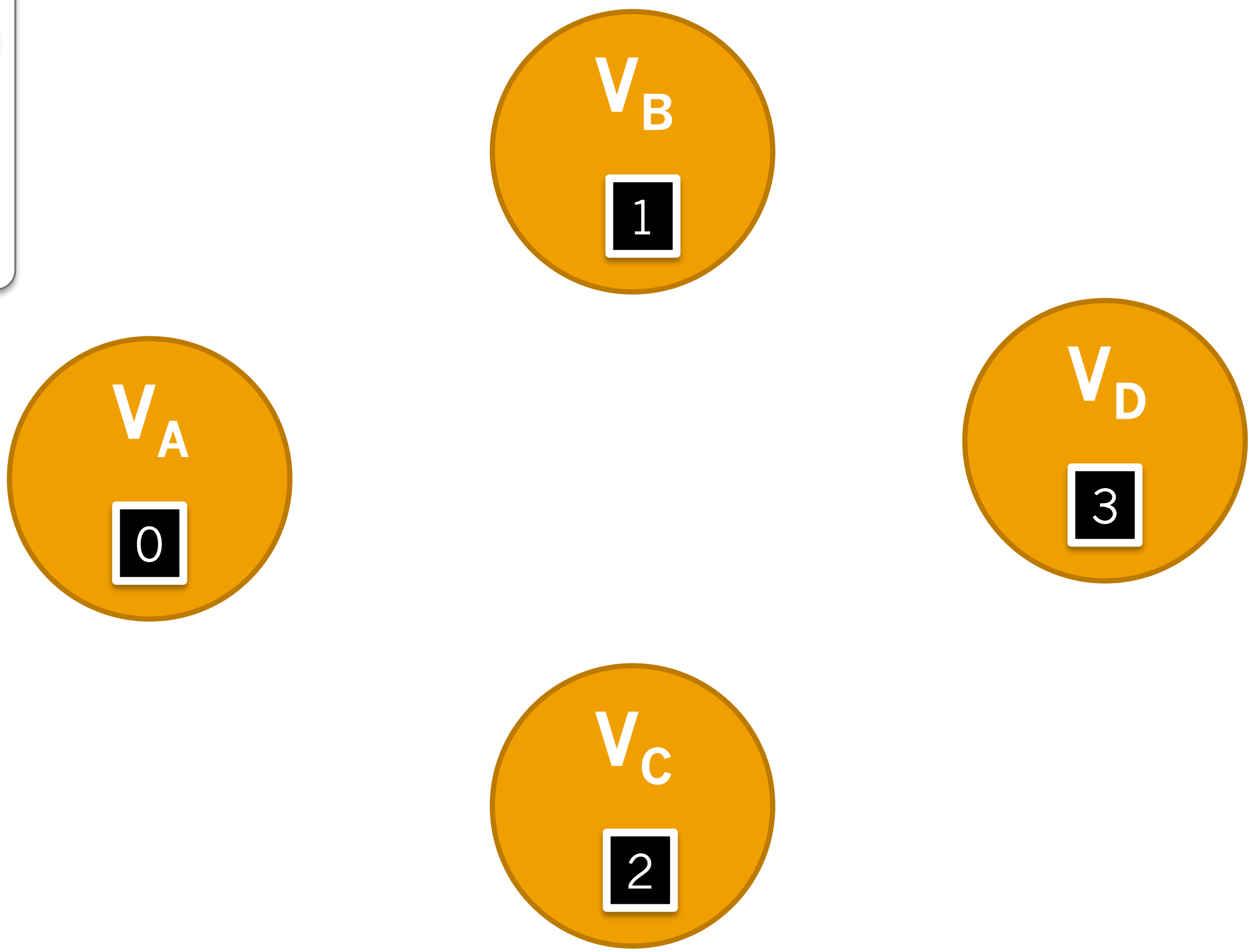
Iteration 2

Example: Shortest path



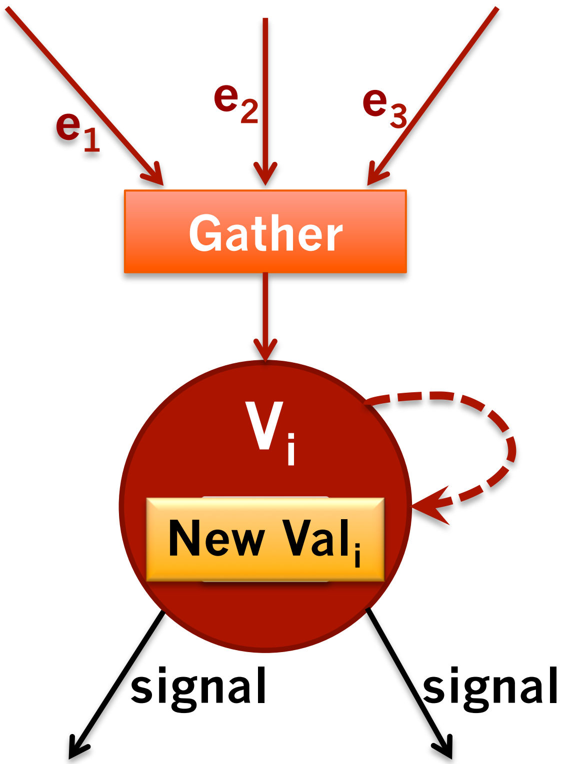
Input Graph

Computation & Communication Pattern



Iteration 3

GraphLab



1. **Gather** values (from neighbors)
2. **Apply** updates to local state
3. **Scatter** signals to your neighbors

What is appealing about these new engines?

Vertex-centric API → Easy to write graph programs → Higher programmer productivity

But …

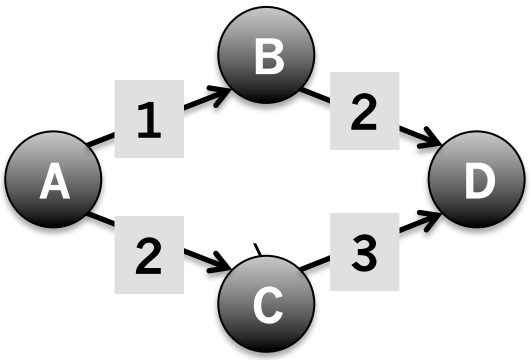
- Can we build a similar vertex-centric simple API?
- … and then map it to SQL, with good performance

The GRAIL API

Advantages:

- Already have SQL in the enterprise stack
- Huge advantage to "one size fits many"
  - $O(N^2)$ headaches when maintaining N specialized systems
  - Economies of scale

Example: Shortest path



Input Graph

Vertex

id	val
A	∞
B	∞
C	∞
D	∞

Edge

src	dest	val
A	B	1
A	C	2
B	D	2
C	D	3

Iteration 1

next

id	val
A	0
B	∞
C	∞
D	∞

message

id	val
B	1
C	2

Iteration 2

next

id	val
A	0
B	1
C	2
D	∞

message

id	val
D	3
D	5

Iteration 3

next

id	val
A	0
B	1
C	2
D	3

message

id	val

The Grail API

T-SQL Code

```
DECLARE @flag int;
SET @flag = 1;
SELECT vertex.id, 2147483647 AS val
INTO next
FROM vertex;
CREATE TABLE message(
    id int
    val int
);
INSERT INTO message values(1,0);
WHILE (@flag != 0)
BEGIN
    SELECT message.id AS id, MIN(message.val) AS val
    INTO
    FROM message
    GROUP BY message.id;
    DROP TABLE message;
    SELECT cur.id AS id, cur.val AS val
    INTO update
    FROM cur, next
    WHERE cur.id = next.id AND cur.val <  next.val;
    U
    SET next.val = update.val
    
    WHERE  next.id = update.id;
    SELECT edge.dest AS id, update.val + 1 AS val
    INTO message
    FROM update, edge
    WHERE edge.src = update.id;
    DROP TABLE cur;
    DROP TABLE update;
    SELECT @flag = COUNT(*) FROM message
END
```

Initialize

Initialize the message table

Aggregate the messages

Update and generate messages for the next iteration

Stop when no new msgs.

```
VertexValType: INT
MessageValType: INT
InitiateVal : INT_MAX
InitialMessage : (1, 0)
CombineMessage: MIN(message)
UpdateAndSend: update=cur.val<getVal()
        if (update) {
          setVal(cur.val)
          send(out, cur.val+1)
        }
End: NO_MESSAGE
```

T-SQL Code

```sql
DECLARE @flag int;
SET @flag = 1;

SELECT vertex.id, 2147483647 AS val
INTO next
FROM vertex;

CREATE TABLE message(
    id int,
    val int
);
INSERT INTO message values(1,0);

WHILE (@flag != 0)
BEGIN
    SELECT message.id AS id, MIN(message.val) AS val
    INTO cur
    FROM message
    GROUP BY message.id;

    DROP TABLE message;

    SELECT cur.id AS id, cur.val AS val
    INTO update
    FROM cur, next
    WHERE cur.id = next.id AND cur.val <  next.val;

    UPDATE next
    SET next.val = update.val
    FROM update, next
    WHERE  next.id = update.id;

    SELECT edge.dest AS id, update.val + 1 AS val
    INTO message
    FROM update, edge
    WHERE edge.src = update.id;

    DROP TABLE cur;

    DROP TABLE update;

    SELECT @flag = COUNT(*) FROM message;
END
```

Initialize

Initialize the message table

Aggregate the messages

Create an update table and only consider updated vertices

Update the next table

Generate the message table for the next iteration

Stop when there are no new messages

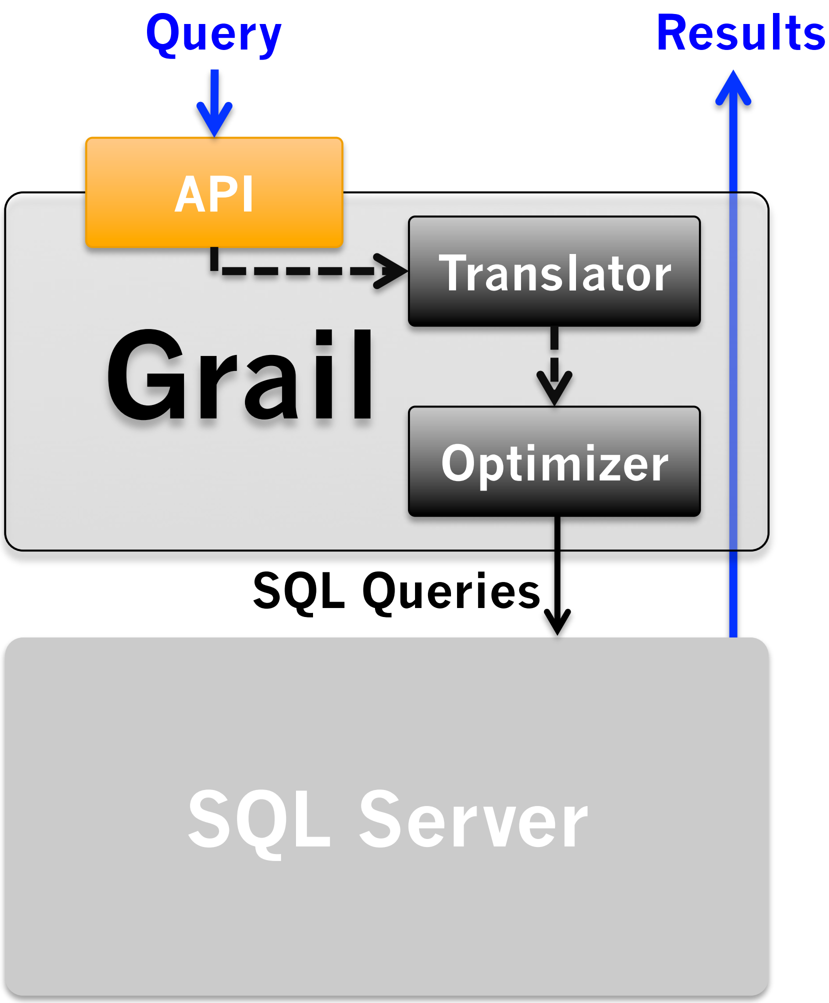
Vertex Centric	Relational Algebra
Receive messages	cur $\longleftarrow \gamma_{id,F_0(val)}(message)$
Mutate value	$next \overset{u}{\longleftarrow} \pi_{next.id,F_1(other.val)} other \bowtie_{id} next$
Send messages	$\pi_{edge.B,F_2(other.val,edge.val)} other \bowtie_{other.id=edge.A} edge$

- Aggregate function (can be a UDAF)
- Scalar computation (can be a UDF)
- Scalar computation (can be a UDF)
- Join attributes control the direction

For single source shortest path

- min
- sum
- identity
- Outgoing edges

Grail: Implementation and Evaluation



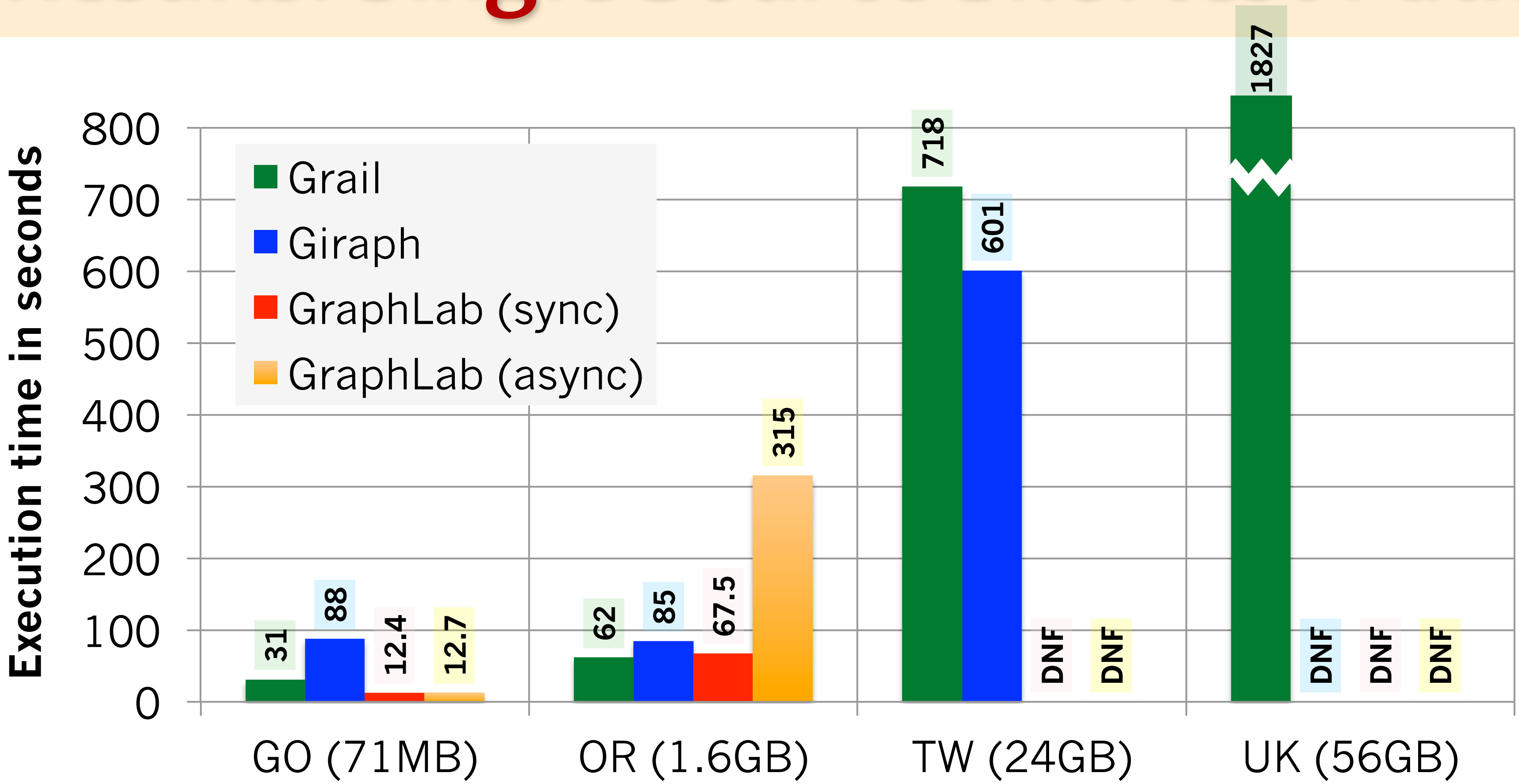
Test Machine (single node)
- Dual 1.8GHz Xeon E2450L
- 96GB of main memory

Compare with
- Giraph (v.1.1.0)
- GraphLab (v 2.2): sync and async

Dataset	#nodes	#edges	size
web-google (GO)	9K	5M	71MB
com-Orkut (OR)	3M	117M	1.6GB
Twitter-10 (TW)	41.6M	1.5B	24GB
uk-2007-05 (UK)	100M	3.3B	56GB

Queries
- Single source shortest-path
- Page Rank
- Weakly connect components

Results: Single Source Shortest Path



Grail is slower than GraphLab for the smallest datasets,

... but catches up as the dataset size grows,

... and can handle the largest datasets, while the other systems fail

Summary: Graph Analytics on RDBMS

Simple API (Grail) addresses the programmer productivity issue

Produces far more robust and deployable solutions than specialized graph engines

Interesting physical schema design and optimization issues

The general case against GraphDB Inc.

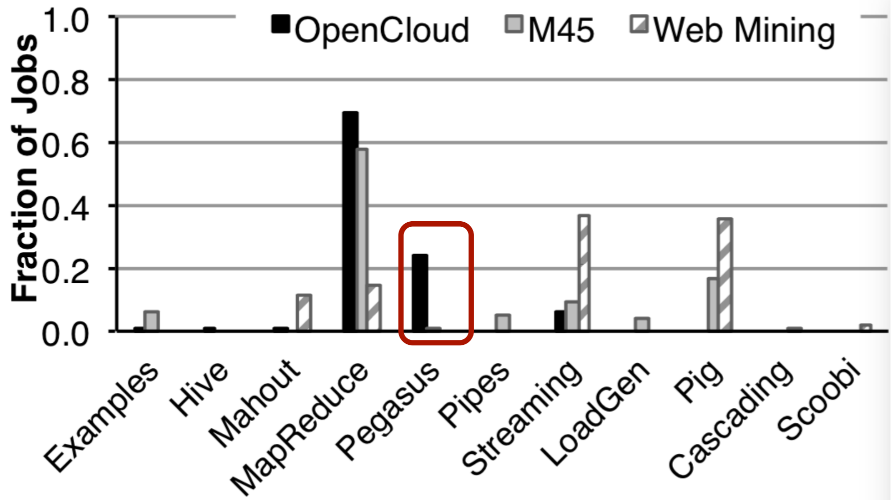


Figure 1: *Fraction of jobs per application type.*

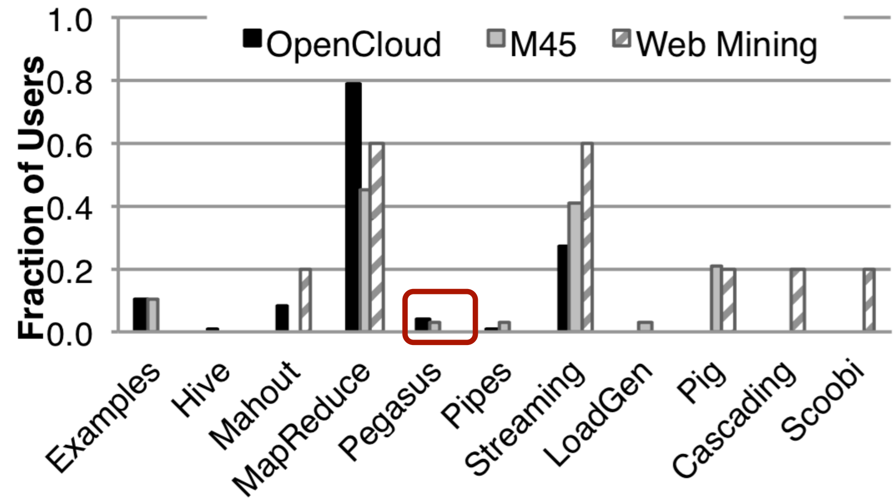


Figure 2: *Fraction of users per application type.*

Thanks!

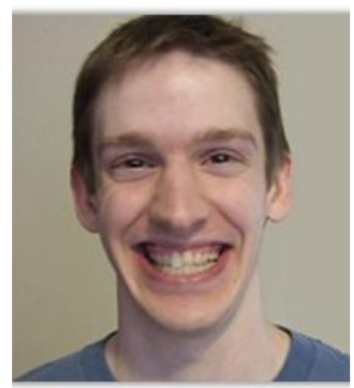
Microsoft GRAY SYSTEMS LAB

NSF

David DeWitt

Jae Young Do

Alan Halverson



Ian Rae