CS 744: POWERGRAPH

Shivaram Venkataraman
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ADMINISTRIVIA

- Midterm grading in progress
- Course Project
Scalable Storage Systems

Datacenter Architecture

Resource Management

Computational Engines

Applications

Machine Learning  SQL  Streaming  Graph

SQL

Streaming

Graph
GRAPH ANALYTICS

Perform computations on graph-structured data

Examples

PageRank
Shortest path
Connected components
...

...
PREGEL: PROGRAMMING MODEL

Message combiner(Message m1, Message m2):
    return Message(m1.value() + m2.value());

void PregelPageRank(Message msg):
    float total = msg.value();
    vertex.val = 0.15 + 0.85*total;
    foreach(nbr in out_neighbors):
        SendMsg(nbr, vertex.val/num_out_nbrs);
NATURAL GRAPHS

(a) Twitter In-Degree

\( \alpha = 1.7 \)
POWERGRAPH

Programming Model:
Gather-Apply-Scatter

Sync / Async execution

Better Graph Partitioning
with vertex cuts
GATHER-APPLY-SCATTER

Gather: Accumulate info from nbrs

Apply: Accumulated value to vertex

Scatter: Update adjacent edges

// gather_nbrs: IN_NBRs
gather(Du, D(u,v), Dv):
    return Dv.rank / #outNbrs(v)

sum(a, b): return a+b

apply(Du, acc):
    rnew = 0.15 + 0.85 * acc
    Du.delta = (rnew - Du.rank)/ #outNbrs(u)
    Du.rank = rnew

// scatter_nbrs: OUT_NBRs
scatter(Du,D(u,v),Dv):
    if(|Du.delta| > ε) Activate(v)
    return delta
EXECUTION MODEL, CACHING

Active Queue

Delta caching
  Cache accumulator value for vertex

  Optionally scatter returns a delta
    Accumulate deltas
SYNC VS ASYNC

Sync Execution
- Gather for all active vertices, followed by Apply, Scatter
- Barrier after each minor-step

Async Execution
- Execute active vertices, as cores become available
- No Barriers! Optionally serializable
DISTRIBUTED EXECUTION

Symmetric system, no coordinator

Load graph into each machine

Communicate across machines to spread updates, read state
GRAPH PARTITIONING

(a) Edge-Cut

(b) Vertex-Cut
Three distributed approaches:
Random Placement

Coordinated Greedy Placement

Oblivious Greedy Placement
OTHER FEATURES

Async Serializable engine
  Preventing adjacent vertex from running simultaneously
  Acquire locks for all adjacent vertices

Fault Tolerance
  Checkpoint at the end of super-step for sync
SUMMARY

Gather-Apply-Scatter programming model
Vertex cuts to handle power-law graphs
Balance computation, minimize communication
DISCUSSION

https://forms.gle/Xs3ibsUCdjynBv7u8
Consider the PageRank implementation in Spark vs synchronous PageRank in PowerGraph. What are some reasons why PowerGraph might be faster?
(a) Twitter PageRank Runtime

(b) Twitter PageRank Comms
NEXT STEPS

Next class: GraphX