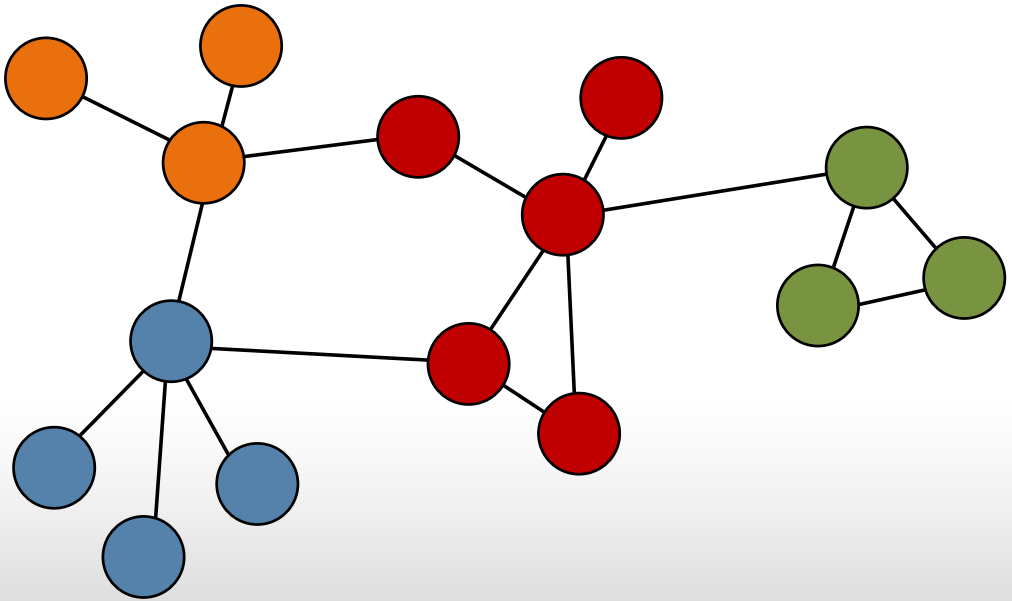
Cost Efficient Large-Scale Graph Analytics

Dr. Joseph Schneible

Technica®

Applications of Graph Analysis

- Social Networks
- WWW
- Medicine
- Natural Language
- Cybersecurity
- Homeland Security
- Local Government



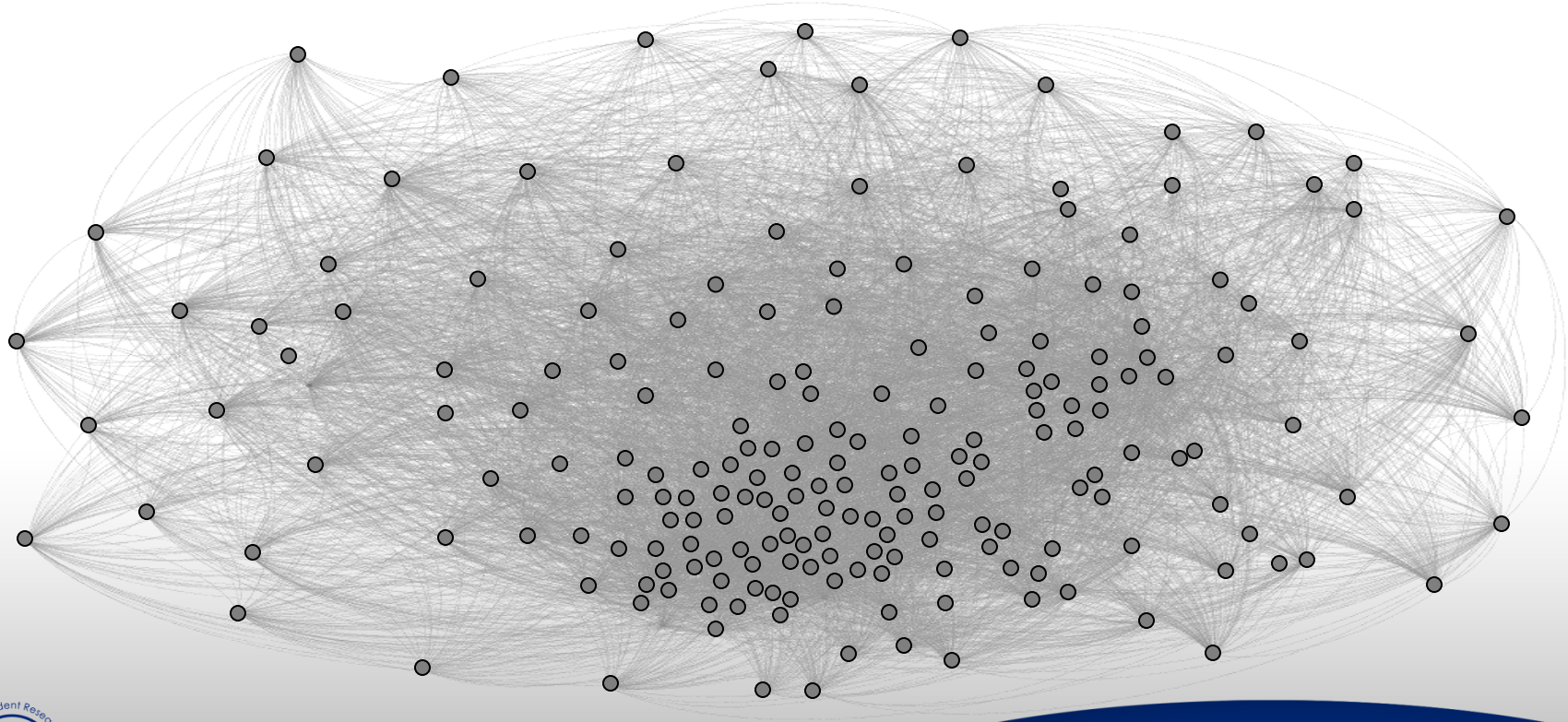
OUTLINE:

- **Graph Analysis**
- **System Design**
- **Performance**

OUTLINE:

- **Graph Analysis**
- System Design
- Performance

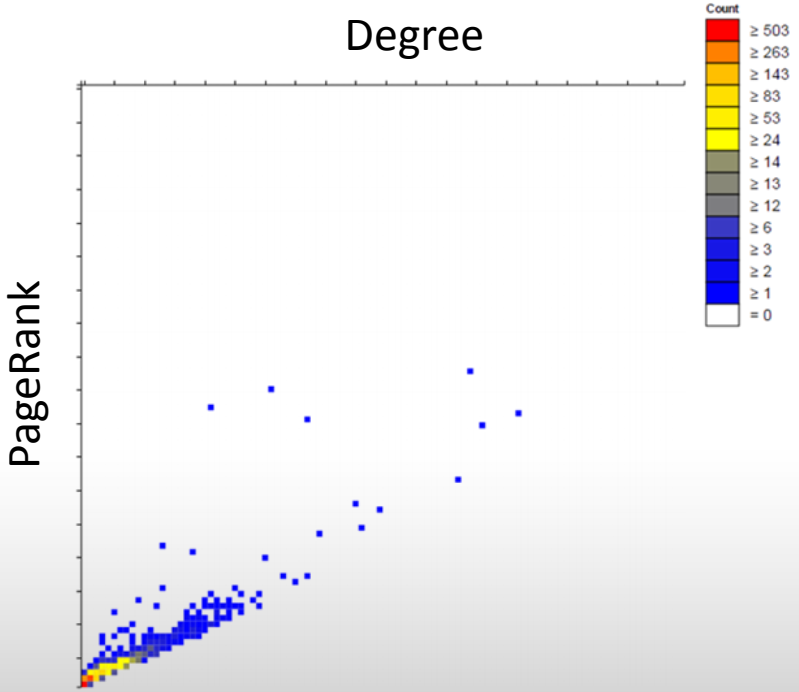
How to bring meaning to this?



Example Algorithms

PageRank	Find Influential Nodes Within a Network
Community Detection	Find Dense Sub-graphs
Belief Propagation	Perform Inference on a Graph

PageRank



- PageRank trends linearly with degree
- Anomalous nodes are above this trend line
- Used to find mastermind of 9/11 attacks
- Can be applied to biological networks, etc

OUTLINE:

- Graph Analysis
- **System Design**
- Performance

Goals

Affordability

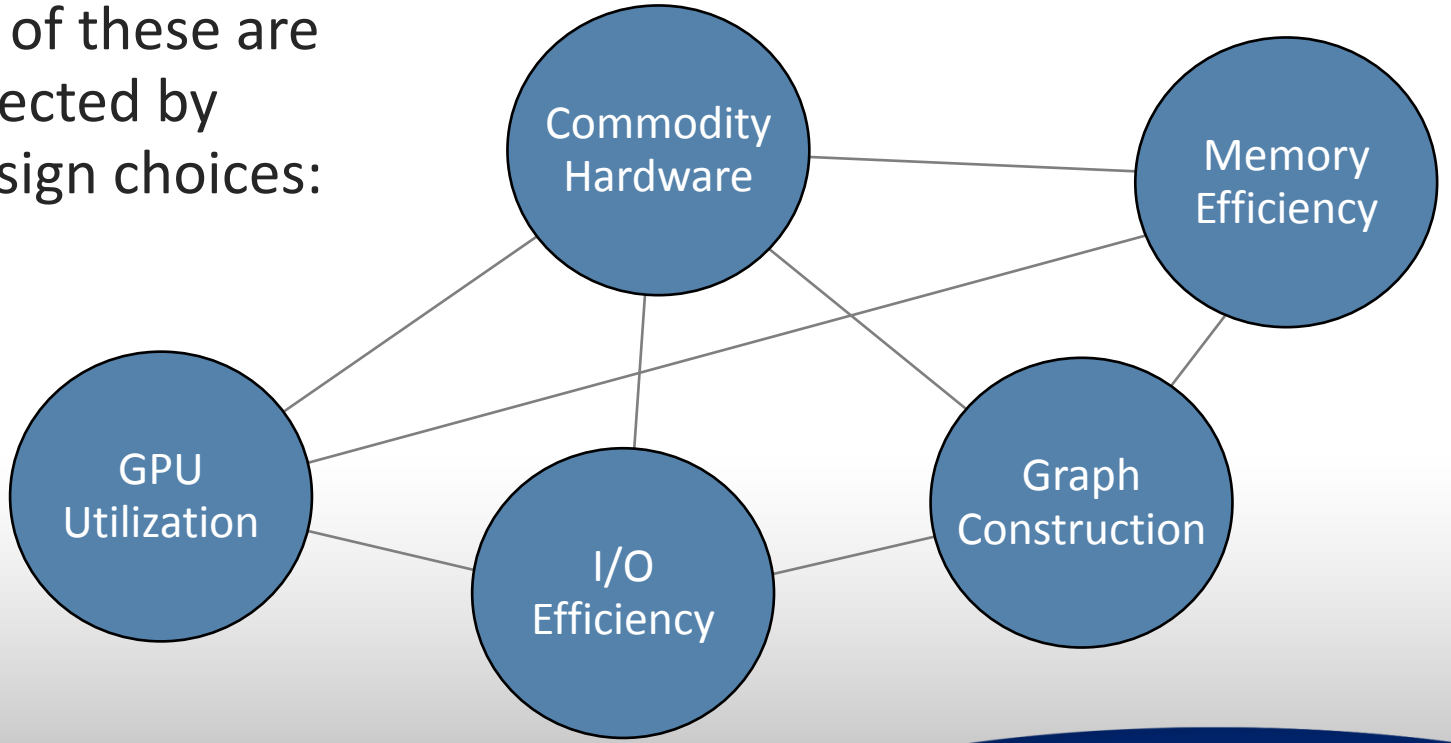
Time Efficiency

Customizability

Meaning

System Approach

- All of these are affected by design choices:

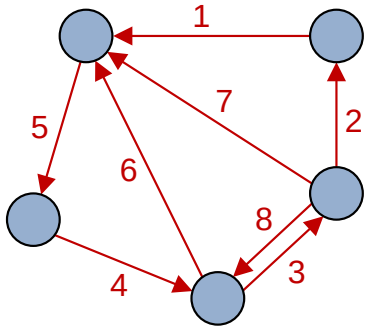


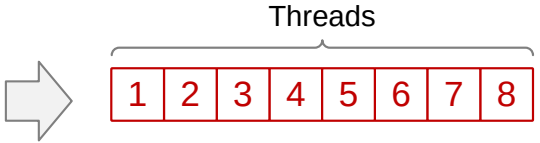
Challenges

Parallelization	Memory Limitations	Irregular Graph Structure
▪ Edges or Vertices?	▪ GB of RAM and vRAM ▪ TB Graphs	▪ Many Nodes with Few Connections ▪ Few Nodes with Many Connections

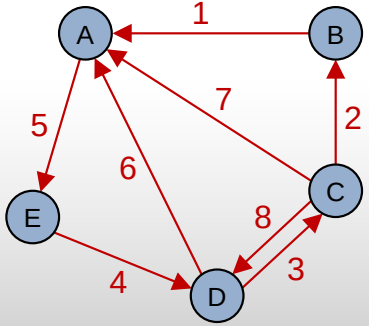
Parallelization Strategies

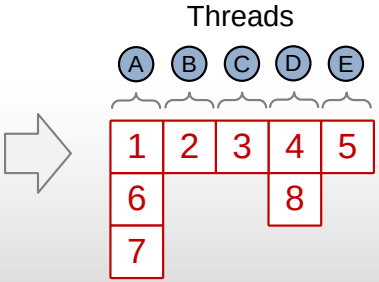
- Edge-wise Distribution:
  - One Operation per Edge
  - Memory for Temporary Data Structures
  - Even Load Balance





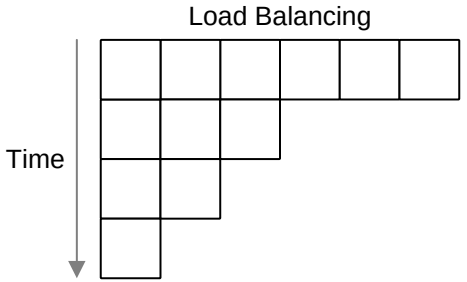
- Vertex-wise Distribution:
  - Multiple Operations per Vertex
  - Uneven Load Balance

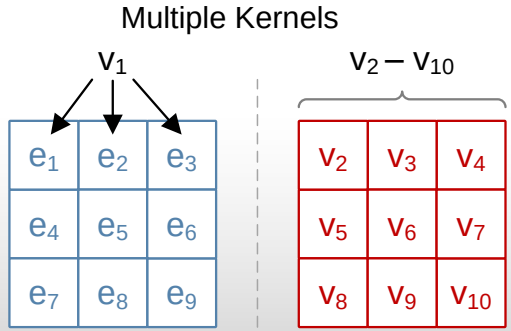




Load Balancing Graph Analysis on the GPU

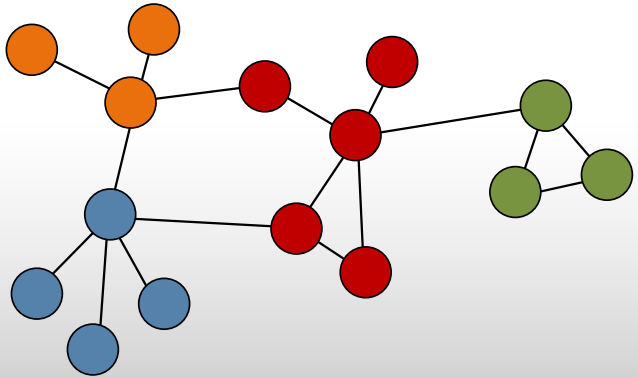
- High degree vertices will dominate computation time
- Created multiple kernels
- Threshold between high and low degree

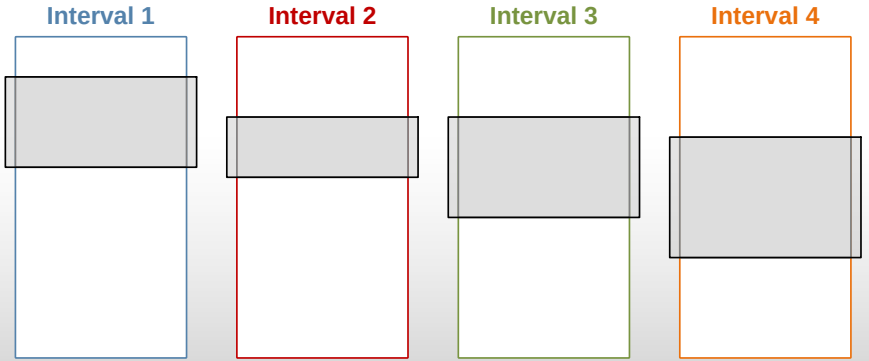




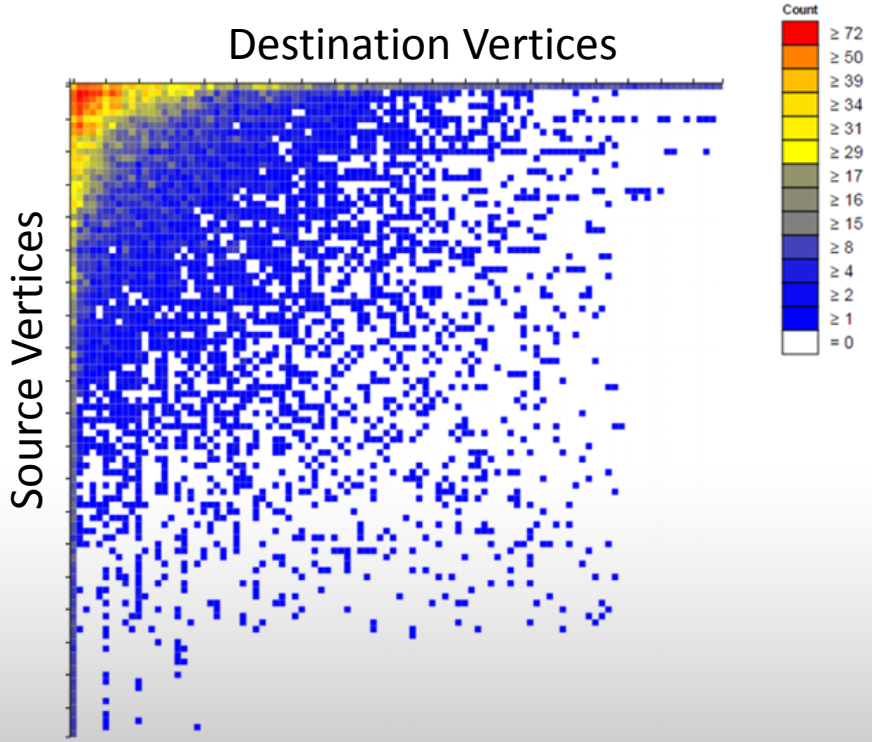
Out-of-Core Graph Processing

- Divide graph into intervals (sets) of vertices
- Gather associated in-edges into a shard
- Order edges in shards such that out-edges are located together in windows





Compression



- Power-law distribution is common in natural graphs
- Compression scheme exploits distribution

Task Analysis

- Use:
  - Graph Meta-data
  - Performance Models
  - Micro-benchmarks
- To:
  - Divide work between CPU and GPU
  - Divide work between kernels

OUTLINE:

- Graph Analysis
- System Design
- **Performance**

PageRank Performance

PageRank:

- 5 Iterations

LiveJournal Graph:

- Vertices: 4.6 Million
- Edges: 77.4 Million

FUNL Desktop System

- 9.5 Seconds

Spark Cluster

- 110.4 Seconds

FUNL Desktop System:

GPU — GeForce GTX TITAN, 2688 CUDA Cores, 928MHz, 6GB vRAM
CPU — Core i7, Quad Core, 3.40GHz
RAM — 16GB (4x4GB), 1333MHz
Storage — HDD, 180MB/s

Spark Cluster:

System: AWS EC2 m1.large
Number of Nodes: 10
Network: Moderate Performance

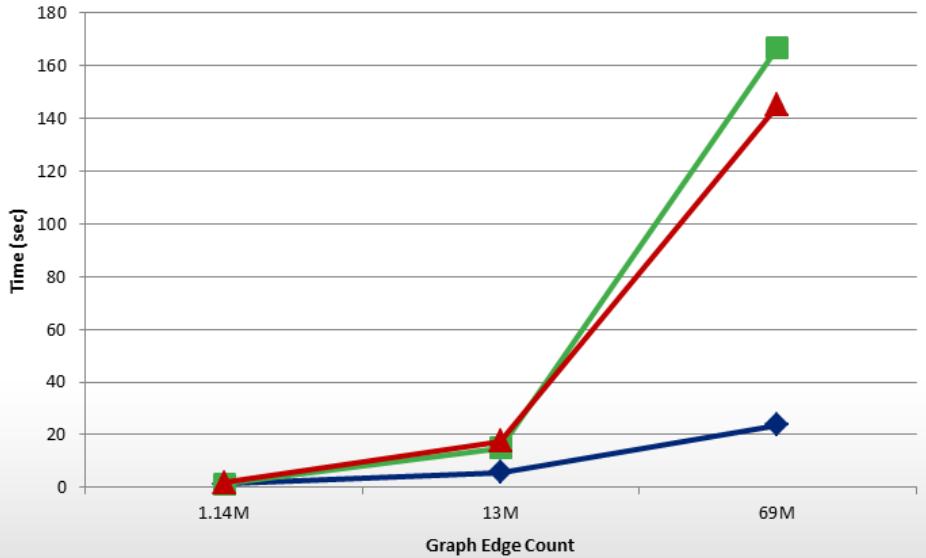
Belief Propagation Performance

FUNL/Quad Core CPU:

- GPU — GeForce GTX TITAN, 2688 CUDA Cores, 928MHz, 6GB vRAM
- CPU — Core i7, Quad Core, 3.40GHz
- RAM — 16GB (4x4GB), 1333MHz
- Storage — HDD, 180MB/s

16 Core Server:

- CPU — Xeon E5-2690, 16 Cores, 2.9GHz
- RAM — 64GB, 1600MHz
- Storage — HDDx6, RAID0, 690MB/s



- https://github.com/GraphChi

Additional Slides

Advantages

- Unique Features:
  - Large scale Graph Analysis on the GPU
  - Task Analysis for Efficient Parallel Processing (on CPU's and GPU's)
  - UI and Interactive Visualization to bring Meaning to Big Data
- Benefits:
  - Big Data Graph Analysis on a Budget
  - Customizability
  - Ease of Use (You don't have to be a data scientist)
  - Reduction in Infrastructure and Energy Needs

Big Data Appliance for Graph Analytics

Gain insight by discovering unknown relationships in big data.	Graph analytics solution that supports pattern discovery and inferencing on large scale data sets.
Achieve a competitive advantage without a large budget.	Purpose-built to solve big data graph problems with commodity hardware.
Ease adoption with a small footprint solution and customizability.	Data-center-friendly appliance with a suite of graph algorithms and flexibility to add custom solutions.

Point of Contact

Joe Schneible

Enterprise Software Solutions
Engineering Group Manager

Email: jschneible@technicacorp.com

LinkedIn: linkedin.com/in/jschneible

Technica Corporation
22970 Indian Creek Dr., Suite 500
Dulles, VA 20166

703.662.2000

technicacorp.com