Lifting for Parallelism

- Remove assumptions made by most sequential algorithms:
  - A single, shared address space.
  - A single “thread” of execution.

- Our goal: Build the Parallel BGL by lifting the sequential BGL.

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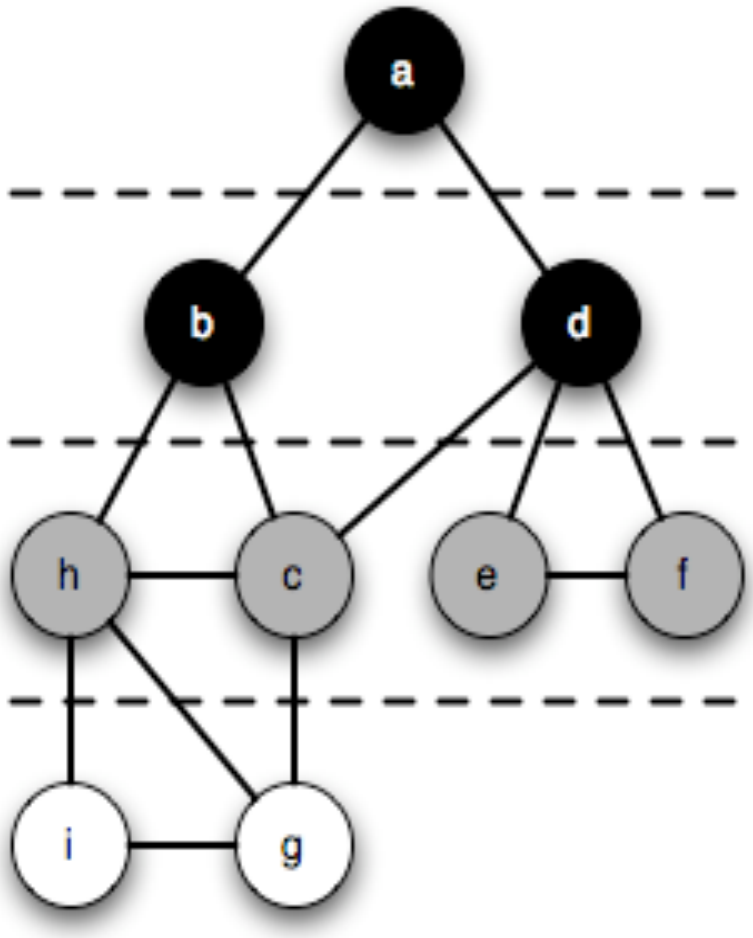
Breadth-First Search

```
put(color, s, Color::gray());
Q.push(s);
while (! Q.empty()) {
  Vertex u = Q.top(); Q.pop();
  for (tie(ei, ei_end) = out_edges(u, g);
    Vertex v = target(*ei, g);
    ColorValue v_color = get(color, v);
    if (v_color == Color::white()) {
      put(color, v, Color::gray());
      Q.push(v);
    } else {
      if (v_color == Color::gray())
      else
    }
  }
  put(color, u, Color::black());
}
```



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Parallellizing BFS?

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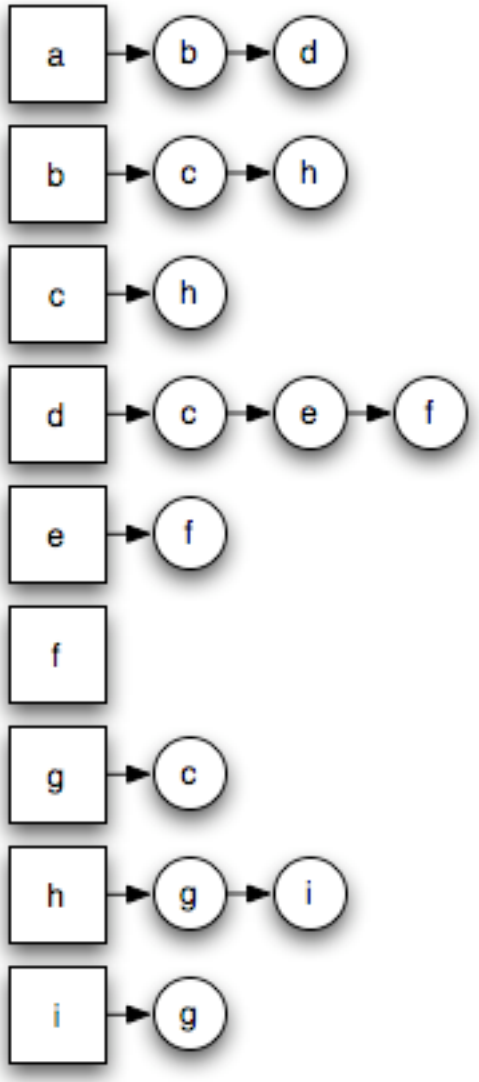

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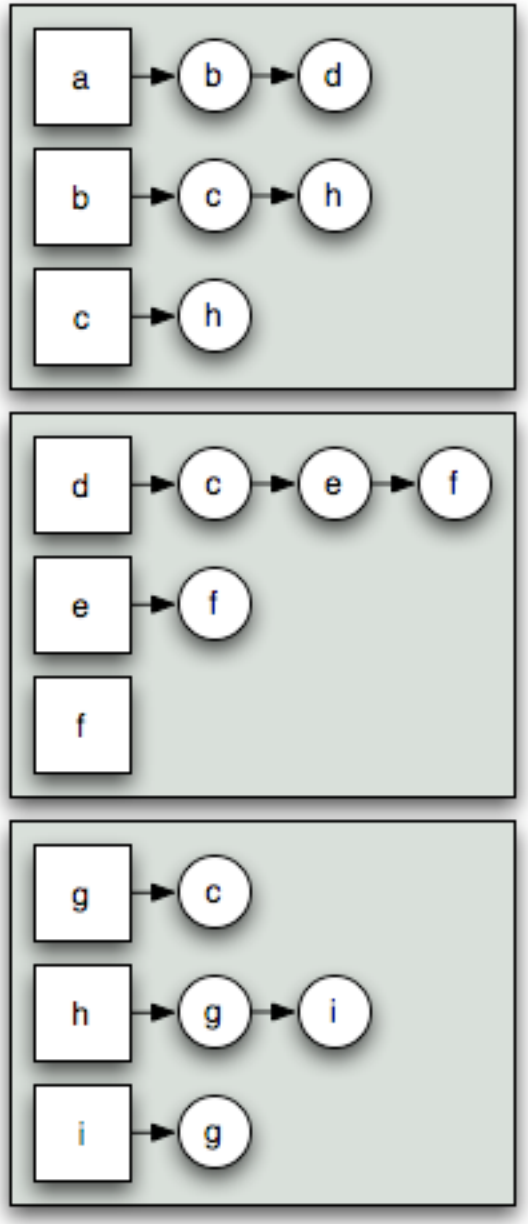
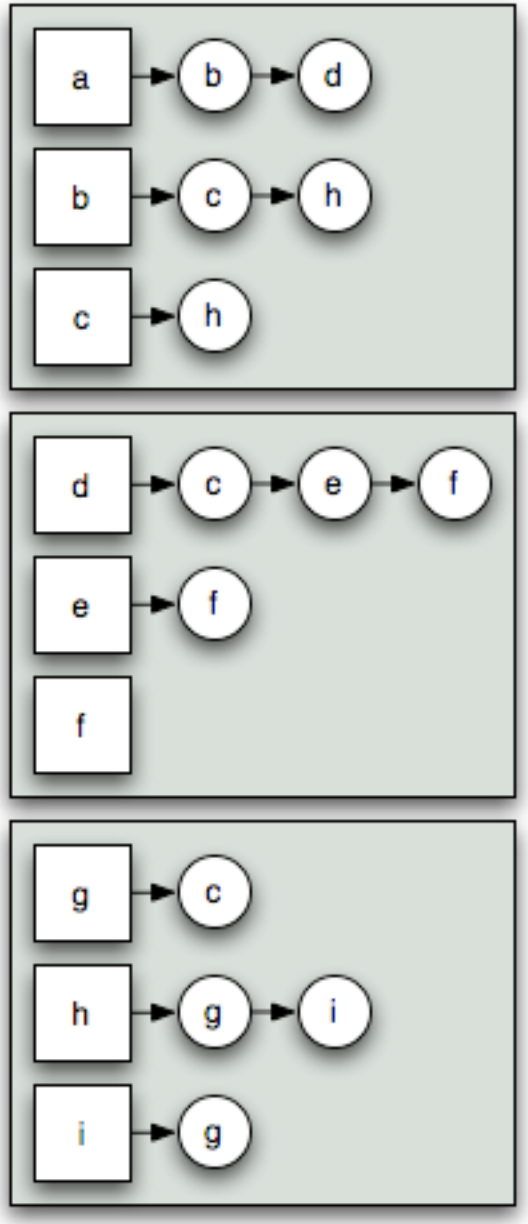


Distributed Graph

- One fundamental operation:
  - Enumerate out-edges of a given vertex
- Distributed adjacency list:
  - Distribute vertices
  - Out-edges stored with the vertices



Parallellizing BFS?

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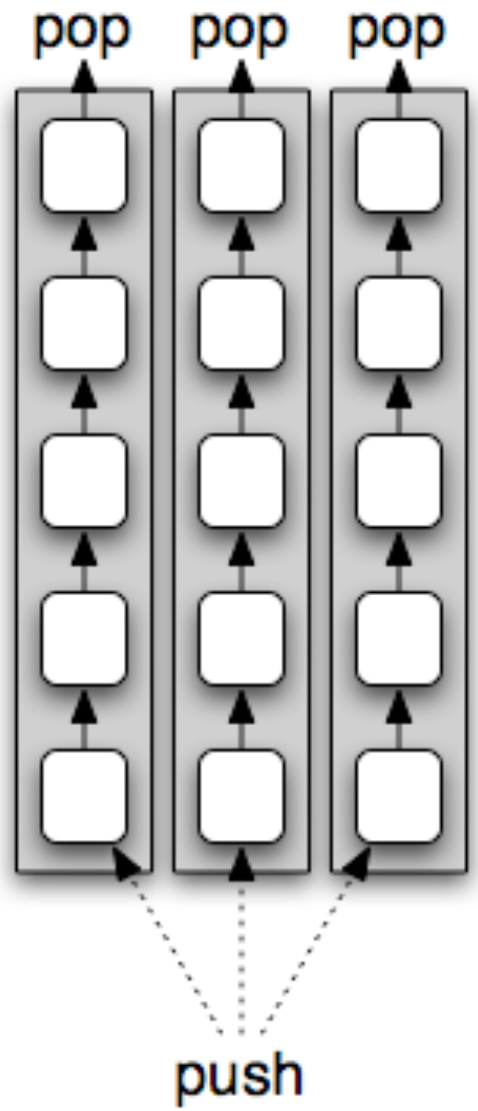
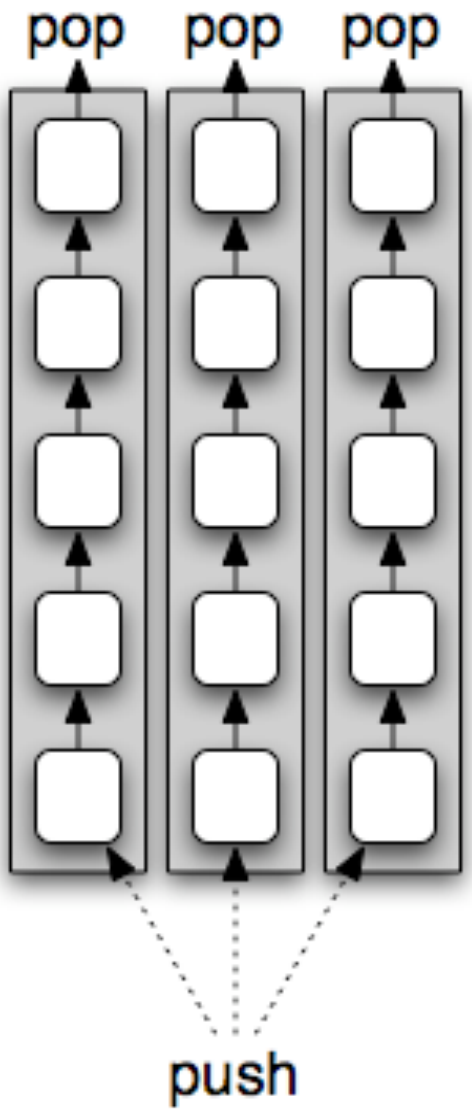


Distributed Queue

- Three fundamental operations:
  - ***top/pop*** retrieves from queue
  - ***push*** operation adds to queue
  - ***empty*** operation signals termination
- Distributed queue:
  - Separate, local queues
  - ***top/pop*** from local queue
  - ***push*** sends to a remote queue
  - ***empty*** waits for remote sends



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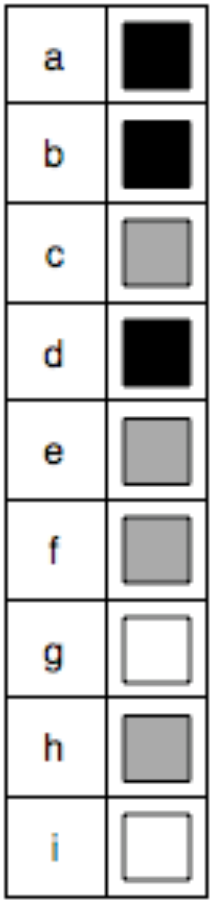

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Parallellizing BFS?

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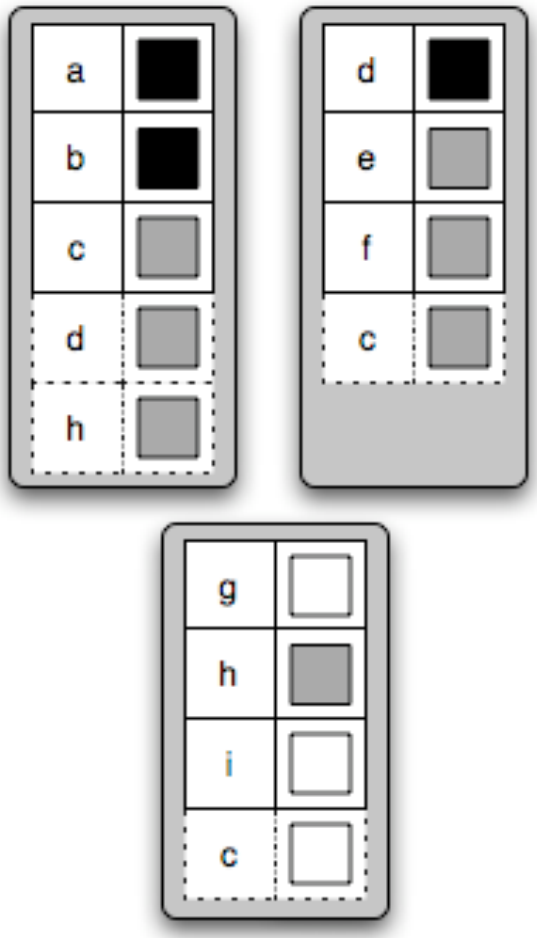

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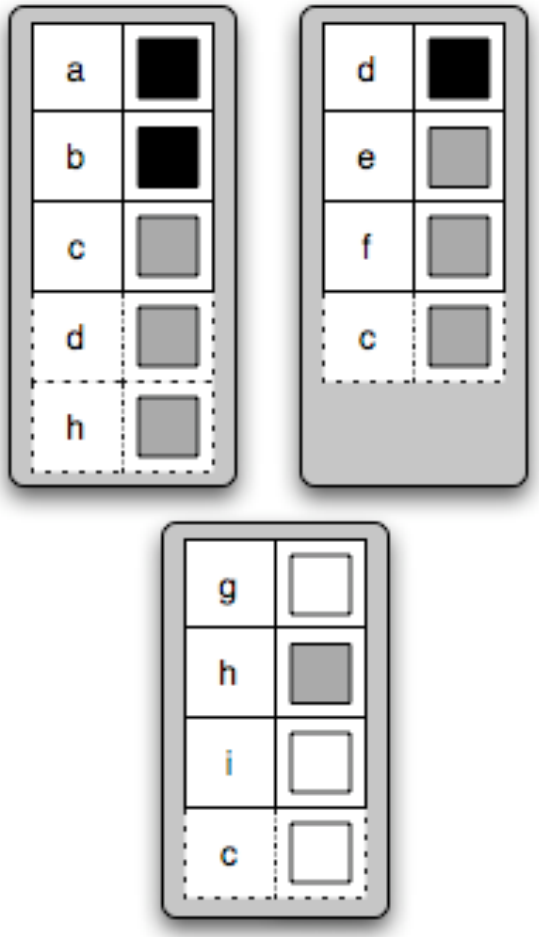
Distributed Property Maps

- Two fundamental operations:
  - ***put*** sets the value for a vertex/edge
  - ***get*** retrieves the value
- Distributed property map:
  - Store data on same processor as vertex or edge
  - ***put/get*** send messages
  - Ghost cells cache remote values
  - Resolver combines **puts**



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“Implementing” Parallel BFS

- Generic interface from the Boost Graph Library

```
template<class IncidenceGraph, class Queue, class BFSVisitor,
         class ColorMap>
void breadth_first_search(const IncidenceGraph& g,
                          vertex_descriptor s, Queue& Q,
                          BFSVisitor vis, ColorMap color);
```

- Effect parallelism by using appropriate types:
  - Distributed graph
  - Distributed queue
  - Distributed property map
- Our sequential implementation is also parallel!
  - Parallel BGL can just “wrap up” sequential BFS

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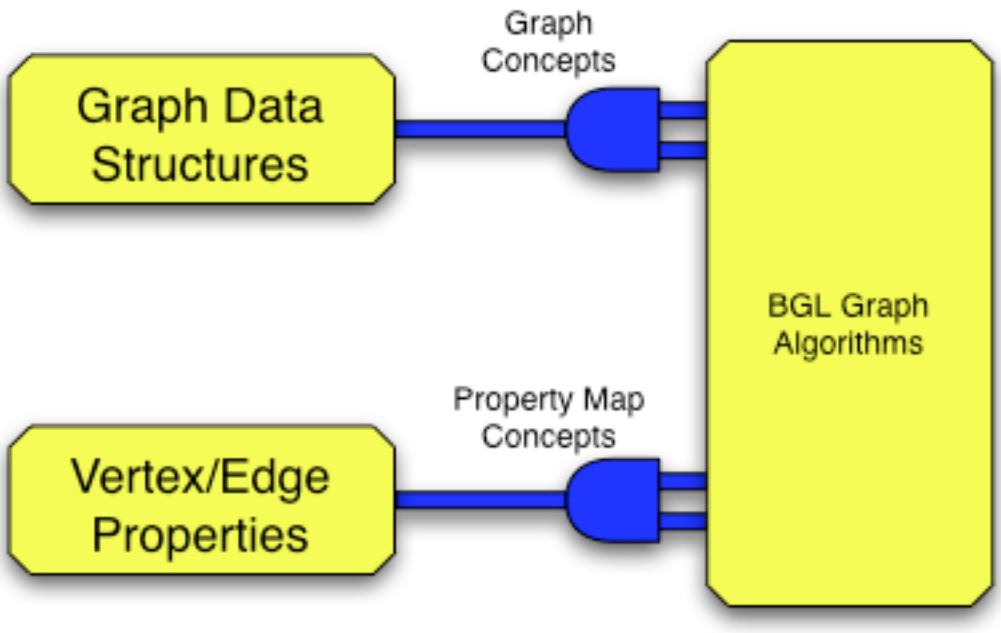
BGL Architecture



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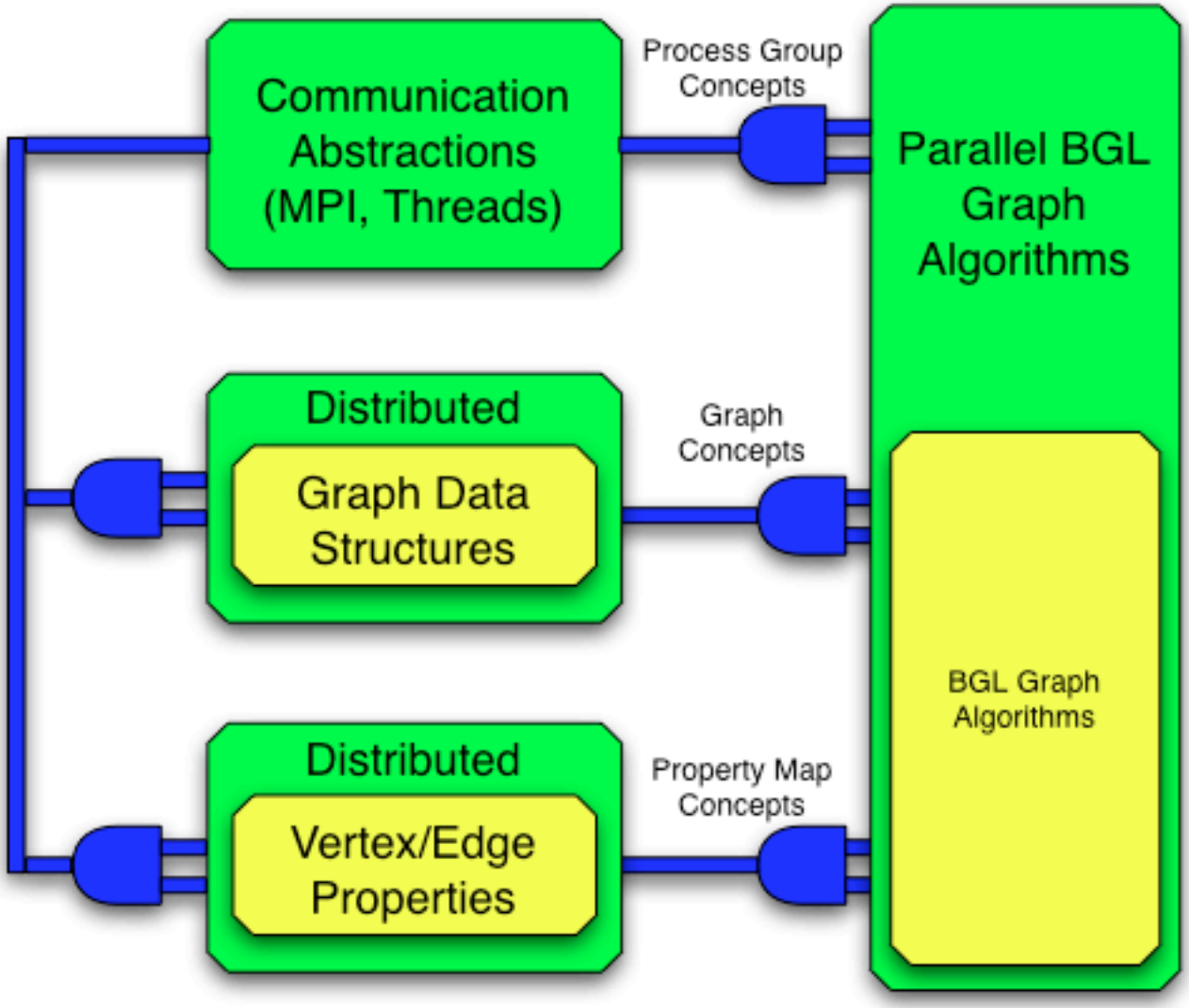
Parallel BGL Architecture



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