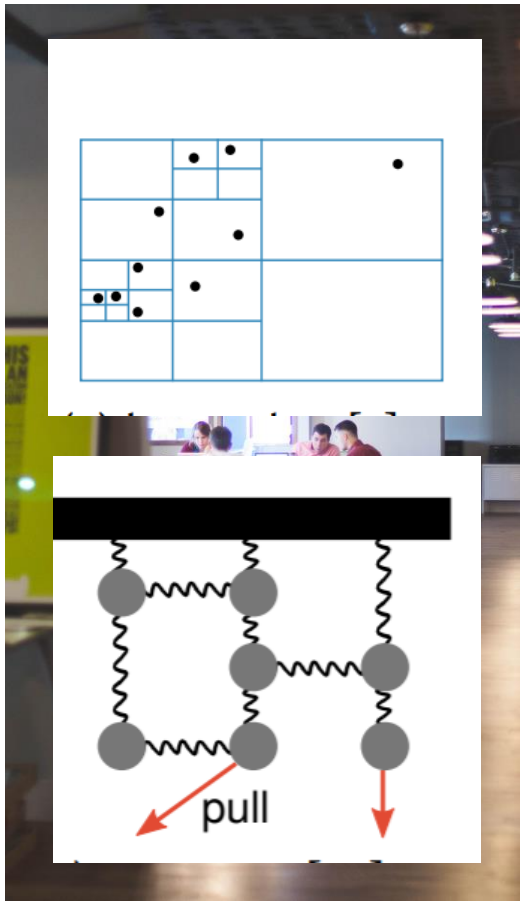
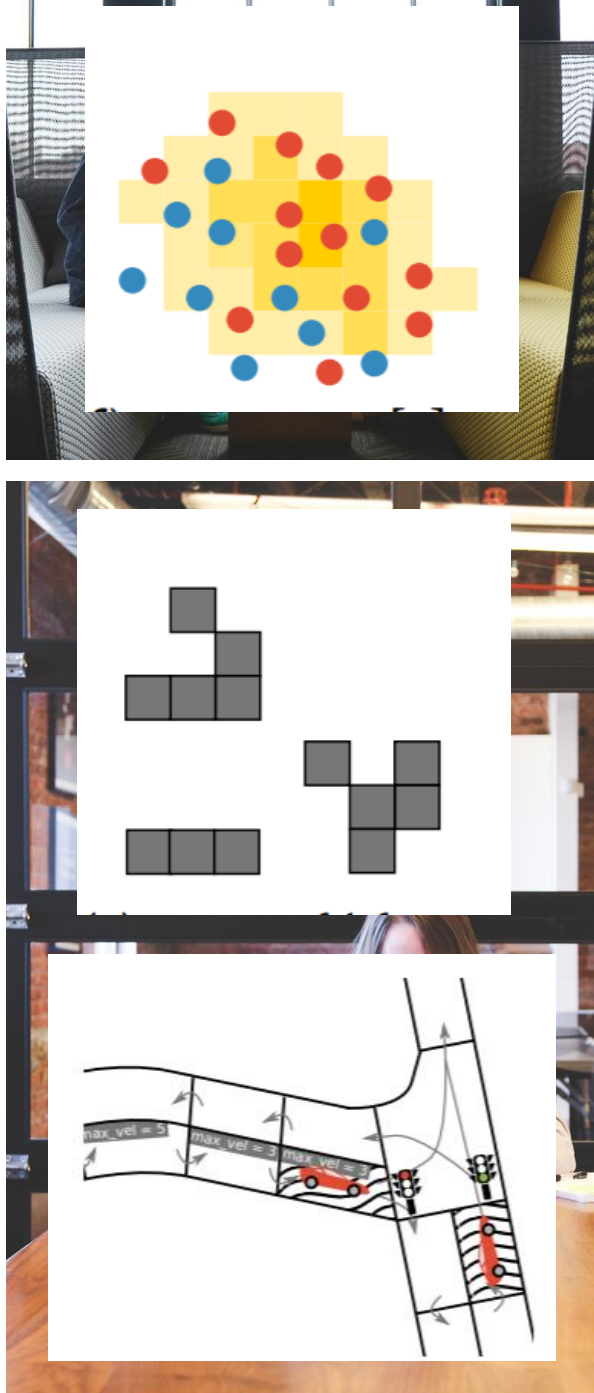
Hidehiko Masuhara
Tokyo Tech
(with Matthias Springer)

A Parallel Object-Oriented Programming Language for GPGPU





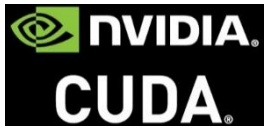
Concurrency model of GPGPU

- At the low levels
  - SIMD (synchronized) execution
  - Distributed memory
- At the higher levels
  - No (or only coarse) synchronization
  - Globally shared memory
- State-of-the-art of programming style
  - Static data allocation + data-parallel

Motivation: wanted a quick prototyping language for GPGPU

interested in GPGPU algorithms

but CUDA/C is too naive...



↓

a scripting language for GPGPU!?

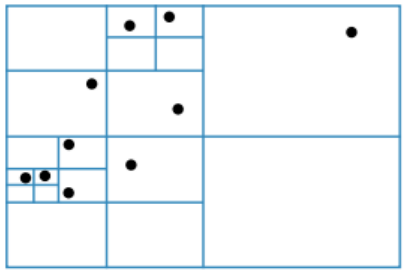
... +

Ikra: data-parallel extension to Ruby

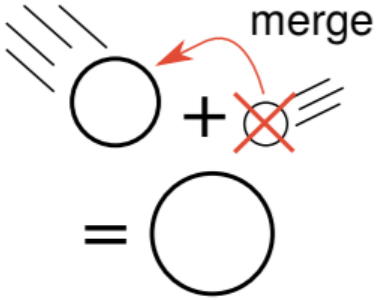
- Concurrency model:
  parallel arrays with map & reduce
- OOP support
  - Optimized memory layout for GPU
  - Parallel arrays (or sets) of objects
  - Dynamic object allocation ←new!

  [ECOOP'19, ISMM'19]

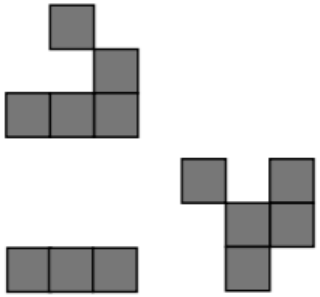
Parallel OOP Applications (demo)



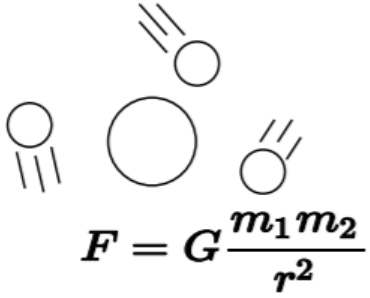
(a) barnes-hut [4]: Parallel Tree Constr.



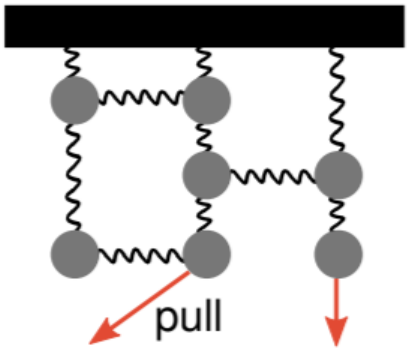
(b) collisions: Particle System



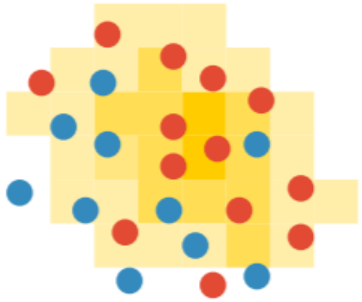
(c) game-of-life: Cellular Automaton



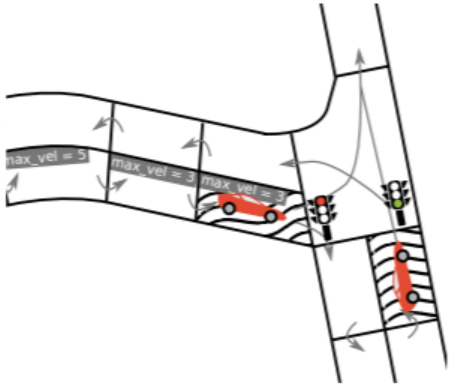
(d) nbody: Particle System



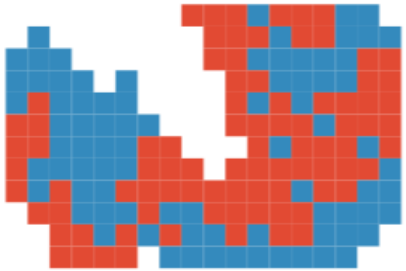
(e) structure [14]: Finite Elem. Method



(f) sugarscape [8]: Agent-based Sim.



(g) traffic [17]: Nagel-Schr. Model



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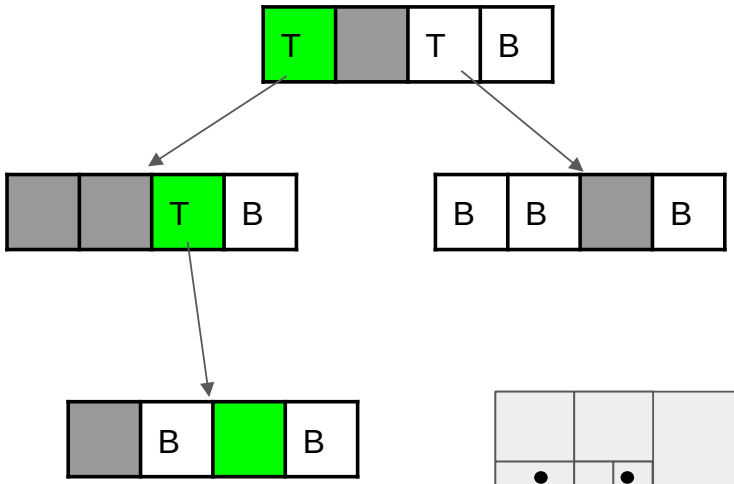
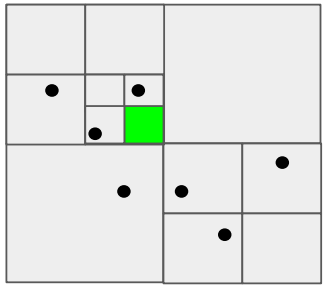
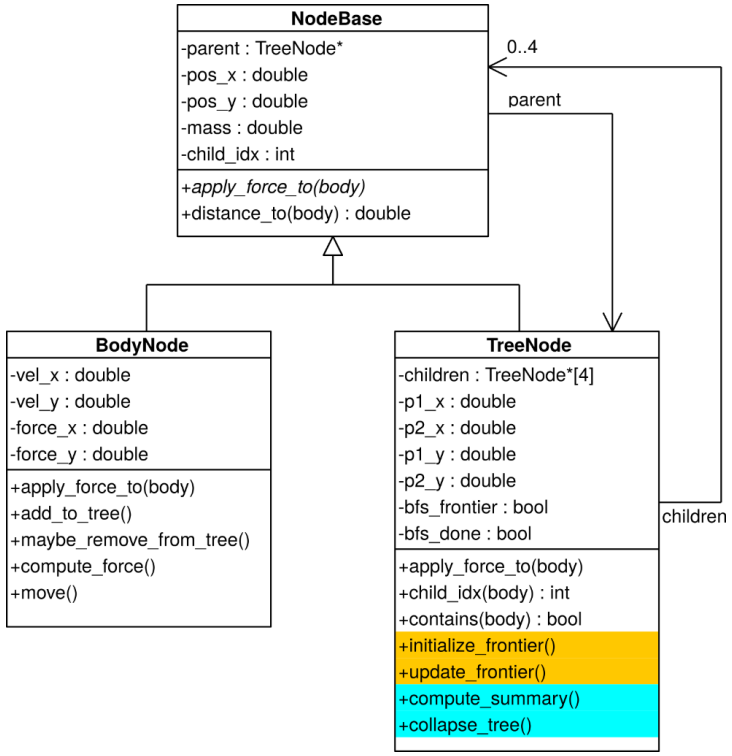
Dynamic allocator enables parallel tree construction

Example 3: Data Structure







OOP helps programming complicated applications

Eg. Traffic simulation

- Road Segment
  - Regular / Junction Expressway / …
- Vehicle
  - Regular / Bus / Emergency / …

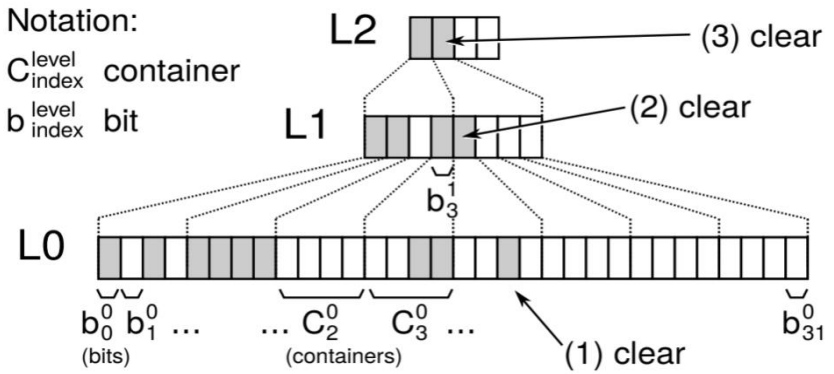
Dynamic memory allocation inside of GPU

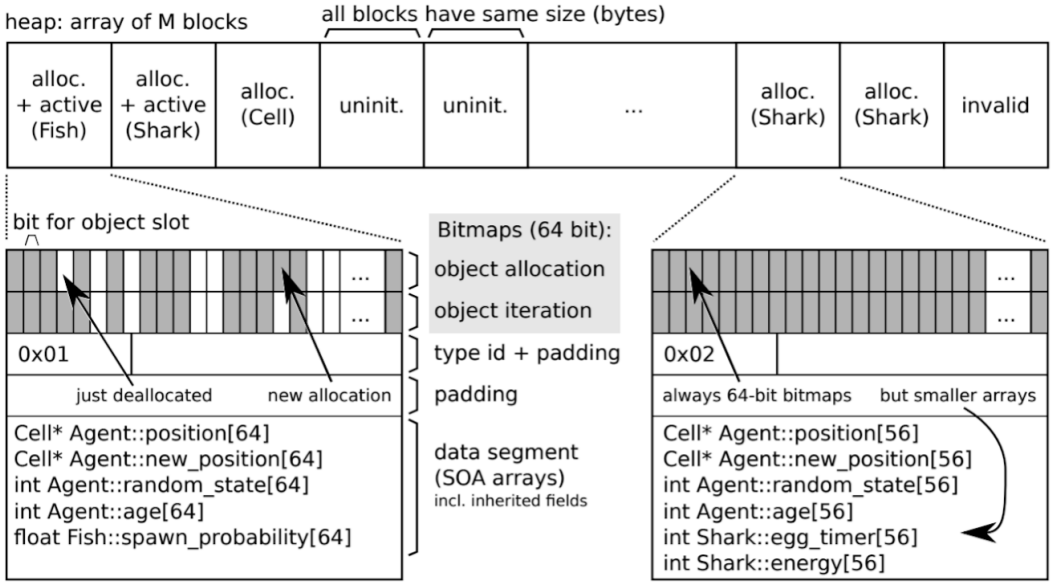
Challenges

- No global locks
- Keep allocated data dense

Approaches

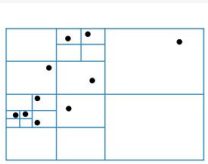
- Block based
- Hierarchical bitmaps





Summary

- OOP helps programming complicated GPGPU applications



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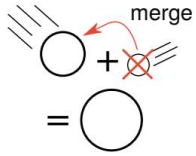

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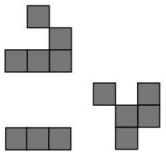

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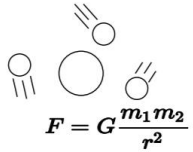

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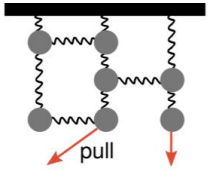

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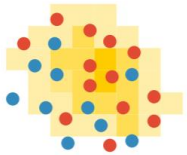

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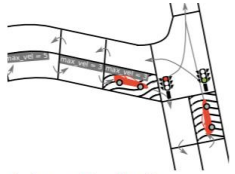

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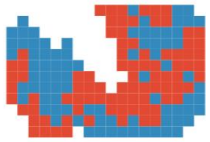

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- A lot of “standard” mechanisms need to be reworked for GPGPU