SparkulAkka: a Simple and Extensible Distributed Simulation System built on Spark and Akka

WSU Vancouver

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Overview

My research focus is on the modeling of forest dynamics and processes.

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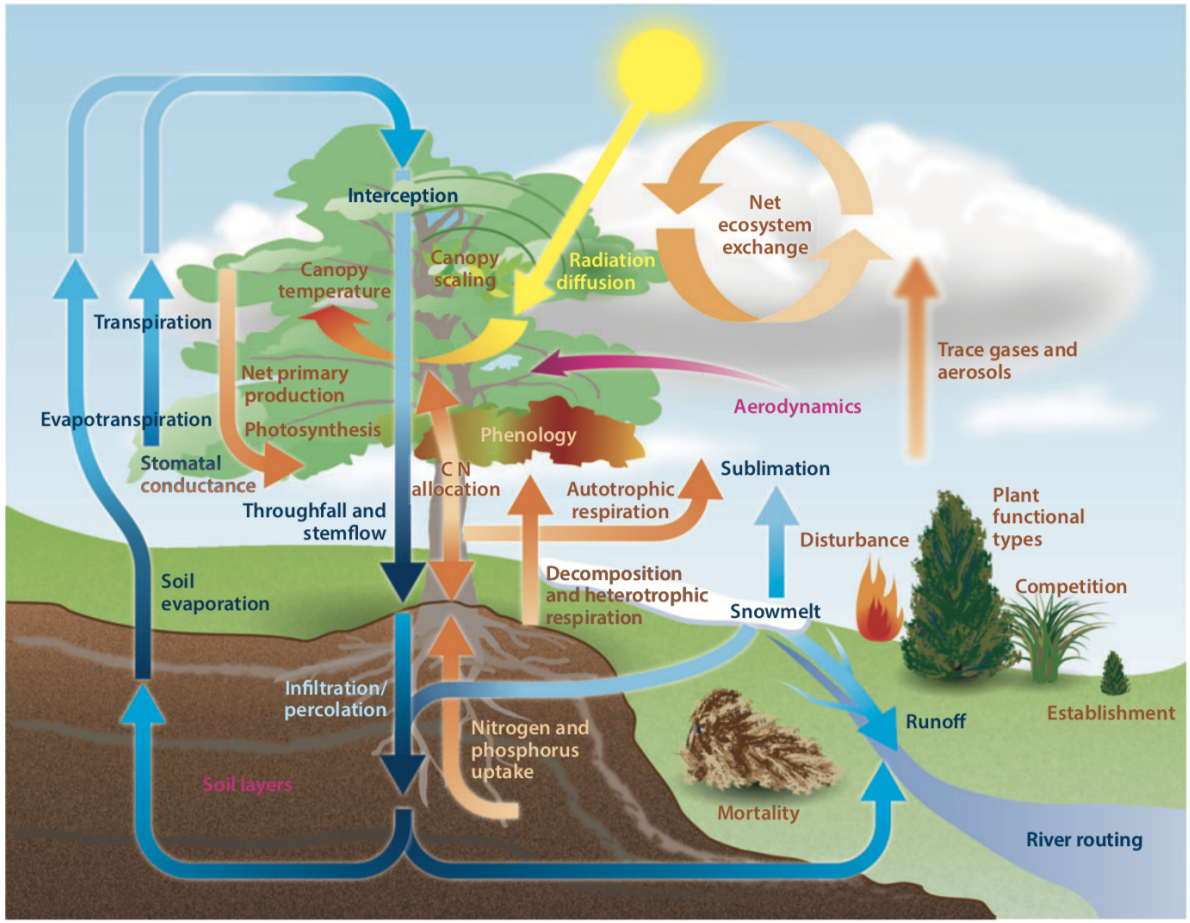

One step at a time...

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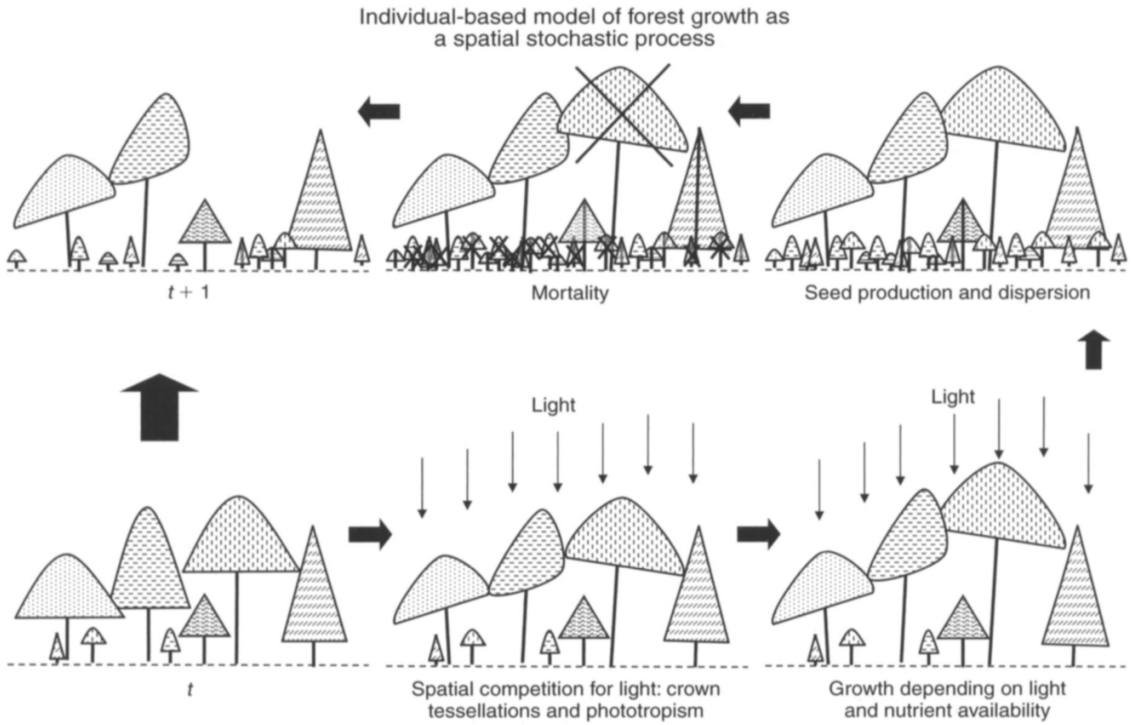

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Data can help, also a computer or 50...

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Interestingly, active forest modeling research, despite the many mentions of computational complexity and data-intensiveness has a gap when it comes to distributed computing.

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- State is maintained privately within each Actor, thus deadlocks and data integrity pose little to no issues in an Actor-oriented system.

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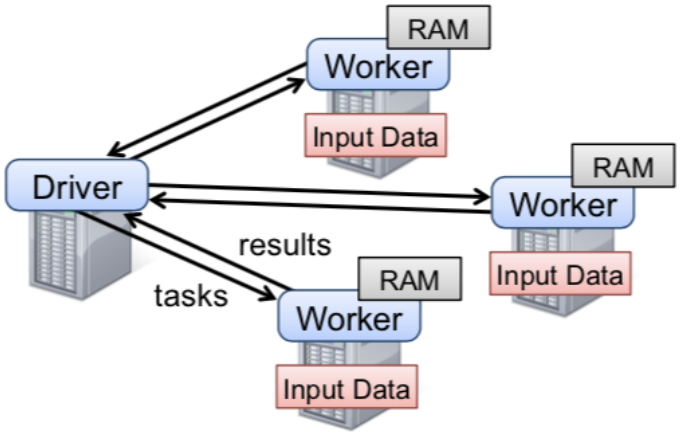
- Spark Runtime:



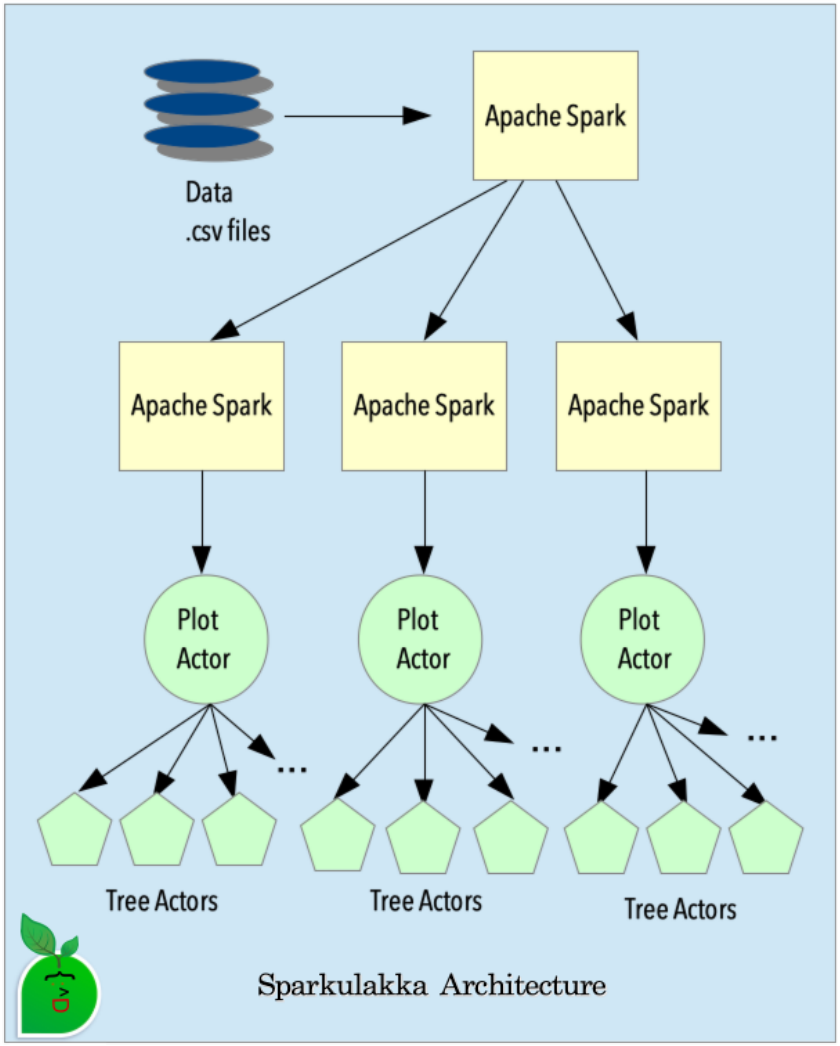


Figure: SparkulAkka architecture and a Harvard Forest flux tower

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- Sample Spark SQL:

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SELECT plot, spcd, AVG(ht), AVG(dia)
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WHERE statuscd = 1 AND diahtcd = 1 AND ht IS NOT NULL
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- WHERE conditions are filter operations. GROUP BY is a groupByKey (with reduce for calculating the final values via AVG). ORDER BY is a sort.

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Load Avg: 4.79, 2.26, 1.89  CPU usage: 98.28% user, 1.71% sys, 0.0% idle     SharedLibs: 213M resident, 63M data, 26M linkedit.
MemRegions: 26043 total, 2365M resident, 165M private, 523M shared. PhysMem: 7747M used (1466M wired), 444M unused.
VM: 1321G vsize, 1297M framework vsize, 0(0) swapins, 0(0) swapouts. Networks: packets: 84178/42M in, 67523/12M out.
Disks: 245300/6196M read, 133444/4176M written.

PID  COMMAND      %CPU  TIME     #TH   #WQ  #PORT MEM    PURG  CMPRS  PGRP PPID STATE    BOOSTS          %CPU_ME %CPU_OTHRS UID  FAULTS
922  screencaptur 0.1   00:00.16 4     2    152   3712K  0B    0B     922  1    sleeping *0[1634+]       0.00000 0.04138    501  5498
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- Whereas the sequential implementation does not:

Processes: 279 total, 3 running, 276 sleeping, 1098 threads 19:25:59
Load Avg: 1.56, 1.58, 1.71 CPU usage: 25.80% user, 2.7% sys, 72.11% idle SharedLibs: 288M resident, 63M data, 37M linkedit.
MemRegions: 25359 total, 2449M resident, 158M private, 446M shared. PhysMem: 7362M used (1424M wired), 829M unused.
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665	screencaptur	0.0	00:02.71	2	1	56	3360K	636K	0B	308	308	sleeping	*0[1]	0.00000	0.00000	501	276900
664	Python	99.5	00:41.89	1/1	0	10	15M	0B	0B	664	632	running	*0[1]	0.00000	0.00000	501	5093
650	com.apple.iC	0.0	00:00.05	2	1	55	3072K	0B	0B	650	1	sleeping	0[1]	0.00000	0.00000	501	4396
632	bash	0.0	00:00.04	1	0	21	892K	0B	0B	632	631	sleeping	*0[1]	0.00000	0.00000	501	1524
631	login	0.0	00:00.01	2	1	31	1032K	0B	0B	631	488	sleeping	*0[9]	0.00000	0.00000	0	1741
630	mdworker_sha	0.0	00:00.07	4	1	61	4580K	0B	0B	630	1	sleeping	*0[1]	0.00000	0.00000	501	8055
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- SimulAkka thus has promise of horizontal scalability.

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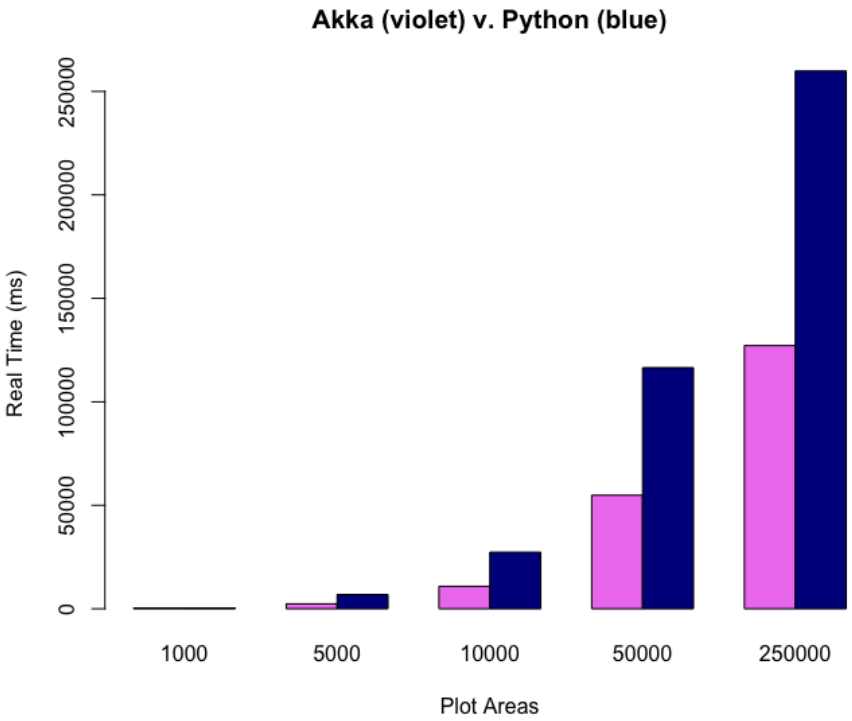
- SimulAkka was run on a system with a quad-core Intel i5 3.4 GHz processor and 8GB of memory - this ran both the SimulAkka-powered simulation, and a simpler (non-Actor model) Python implementation for comparison.

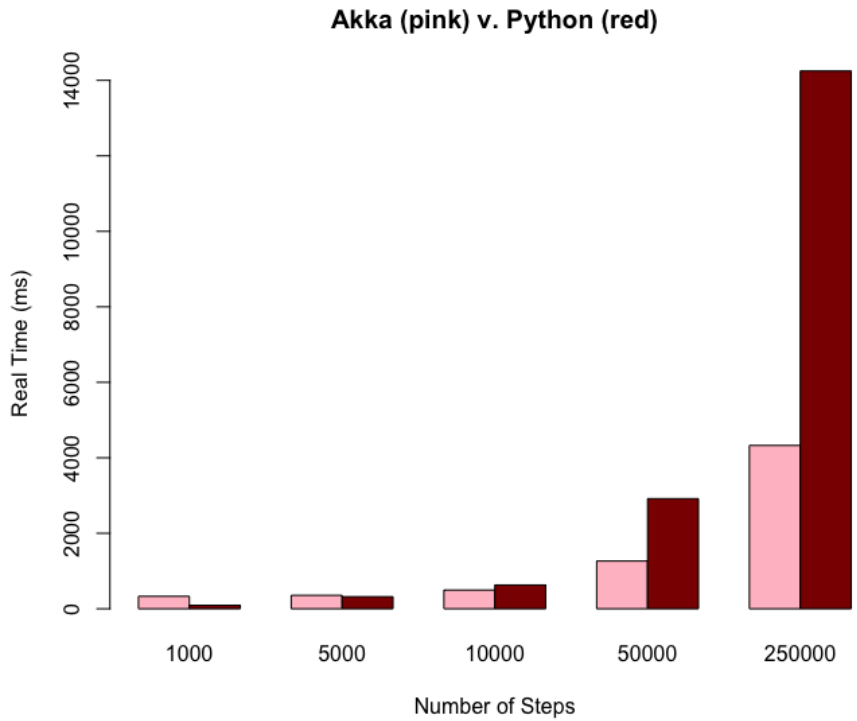
Overview

Sparkulation performance (versus R)

- Spark was 20% faster than R in my trial run of a single, relatively small (73mb) CSV that easily fits in most home computer's memory. Processing the entirety (21 gigabytes+) of FIADB data would give a significant advantage to Spark, both in feasibility and performance.

SimulAkka performance





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```
void Plant() {
  //#pragma omp parallel for num_threads(NUM_THREADS)
  for (unsigned short s = 0; s < nS; s++) {
    cohort[K].s = s;
    //          if(OH==0) value[s].caTotal=FA/2;
    //          cohort[K].n = (species[s].n /(double)nP) *
    //(value[s].caTotal/FA);
    cohort[K].n = species[s].n / (double)nP;
    cohort[K].d = species[s].d;
    cohort[K].h = height(cohort[K]);
    cohort[K].r = radius(cohort[K]);
    K++;
    value[s].kTotal++;
    value[nS].kTotal++;
  }
}
...
```

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- Make attractive and healthy ecology codebase in order to encourage code reuse and maintenance by scientific community

Questions?