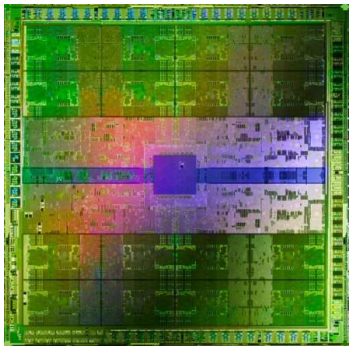
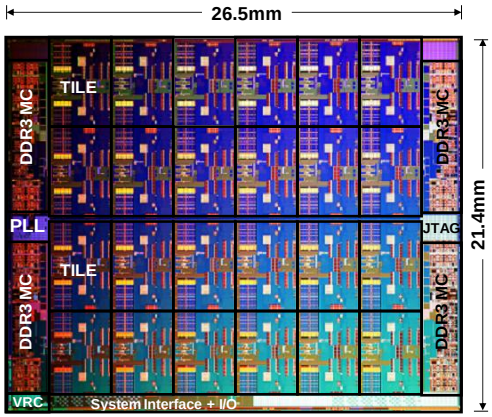
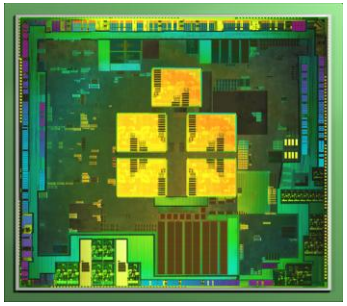


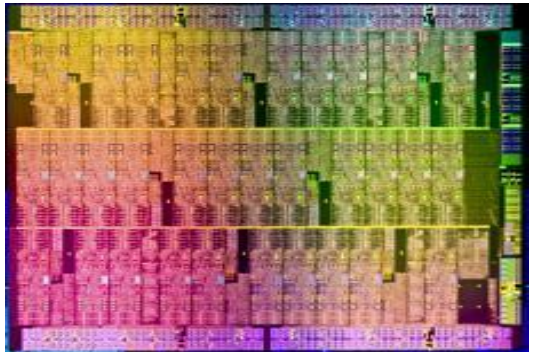
NVIDIA GTX 480 processor



Intel labs 48 core SCC processor



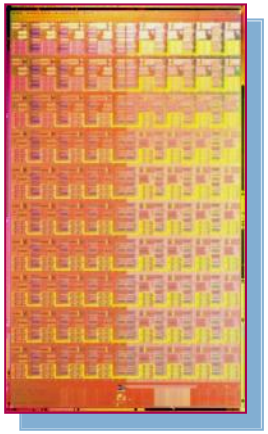
NVIDIA Tegra 3 (quad Arm Corex A9 cores + GPU)



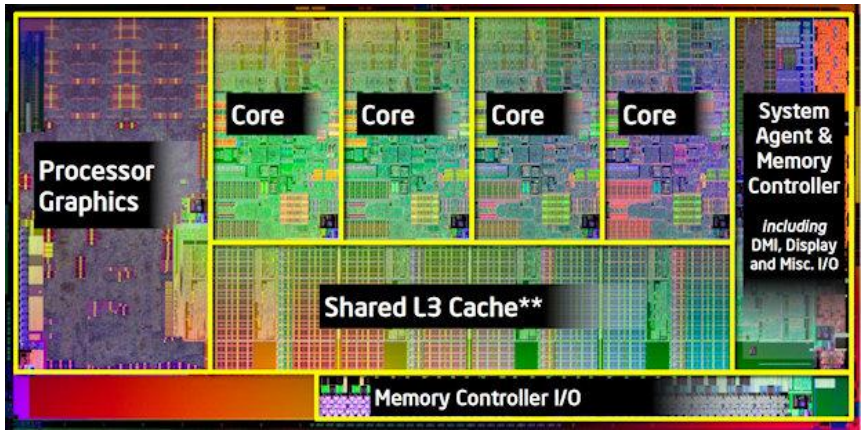
An Intel MIC processor

Resilient software using modular programming techniques that normal humans can use (and understand)

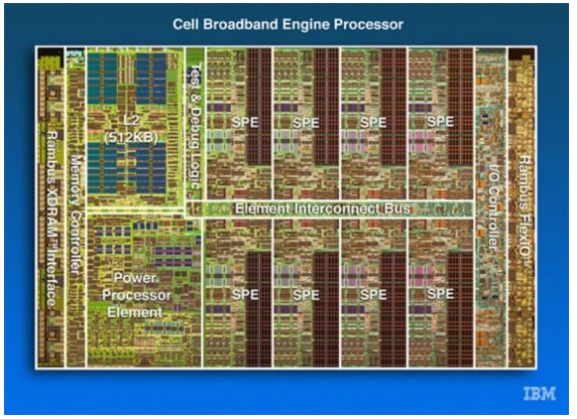
Tim Mattson (Intel Labs)



Intel Labs 80 core Research processor

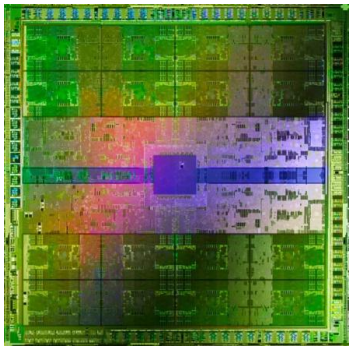


Intel "Sandybridge" processor

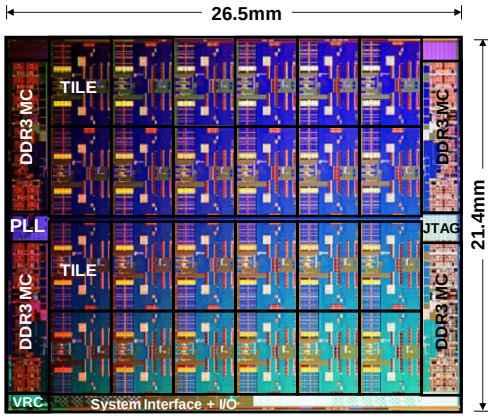


IBM Cell Broadband engine processor

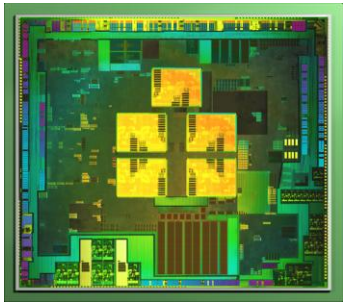
Other than the Intel lab's research processors. Die photos from UC Berkeley CS194 lecture notes



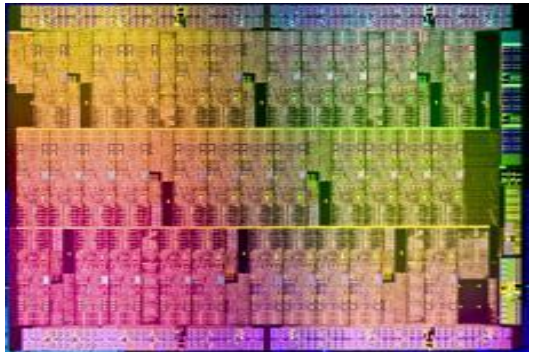
NVIDIA GTX 480 processor



Intel labs 48 core SCC processor



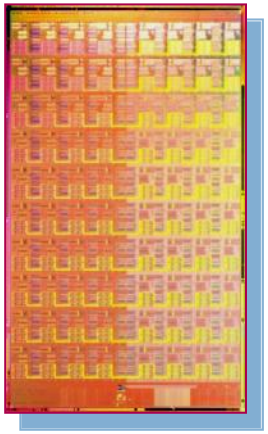
NVIDIA Tegra 3 (quad Arm Corex A9 cores + GPU)



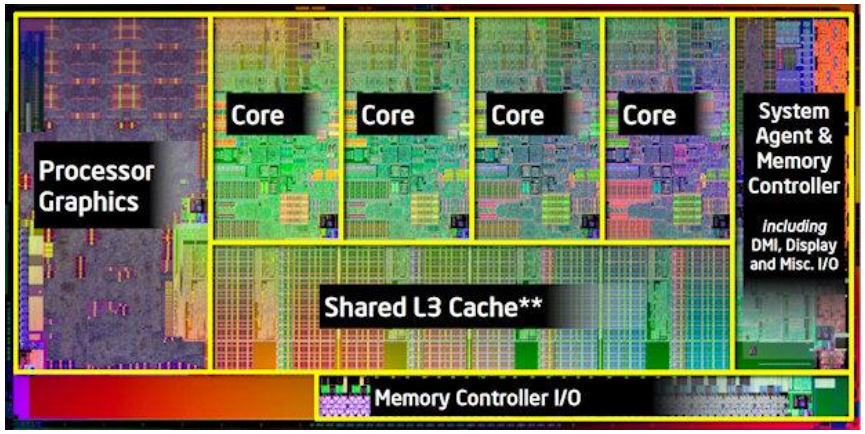
An Intel MIC processor

Parallel programming principles: Designed around the Human programmer (not the computer)

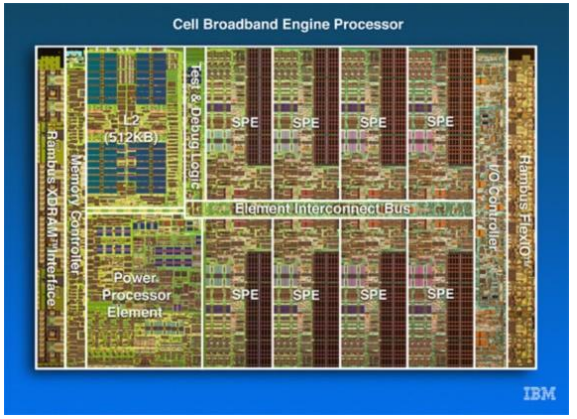
Tim Mattson (Intel Labs)



Intel Labs 80 core Research processor



Intel "Sandybridge" processor



IBM Cell Broadband engine processor

Other than the Intel lab's research processors. Die photos from UC Berkeley CS194 lecture notes

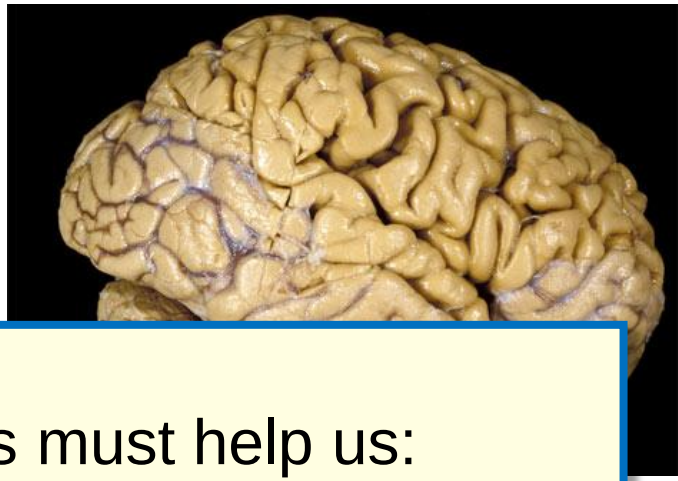
Psychology of Programming in one slide

- Human reasoning is model based … Programming is a process of successive refinement of a problem over a hierarchy of models.[1]
- The models are informal, but detailed enough to support simulation.
- Programmers use an informal, internal notation based on the problem, mathematics, programmer experience, etc.
  - Within a class of programming languages, the solution generated is only weakly dependent on the language.[2] [3]
- Opportunistic Refinement:[4]
  - Progress is made at multiple levels of abstraction with effort focused on the most productive level.

- **[1] R. Brooks, "Towards a theory of the comprehension of computer programs", Int. J. of Man-Machine Studies, vol. 18, pp. 543-554, 1983.**
- **[3] M. Petre and R.L. Winder, "Issues governing the suitability of programming languages for programming tasks. "People and Computers IV: Proceedings of HCI-88, Cambridge University Press, 1988.**
- **[4] M. Petre, "Expert Programmers and Programming Languages", in [Hoc90], p. 103, 1990.**
- **[2] S. P. Robertson and C Yu, "Common cognitive representations of program code across tasks and languages", int. J. Man-machine Studies, vol. 33, pp. 343-360, 1990.**

Psychology of Programming in one slide

- Human reasoning is model based … Programming is a process of successive refinement of a problem over a hierarchy of models.[1]



- This means our programming principles must help us:
  - Define a productivity layer for domain-specialist-programmers that supports model-building in the application domain.
  - Expose a machine model programmers can understand (programmers run mental simulations to understand execution)
  - Allow programmers to move back and forth within the hierarchy of models (Opportunistic refinement).
    - Abstract the hardware but don't hide it!

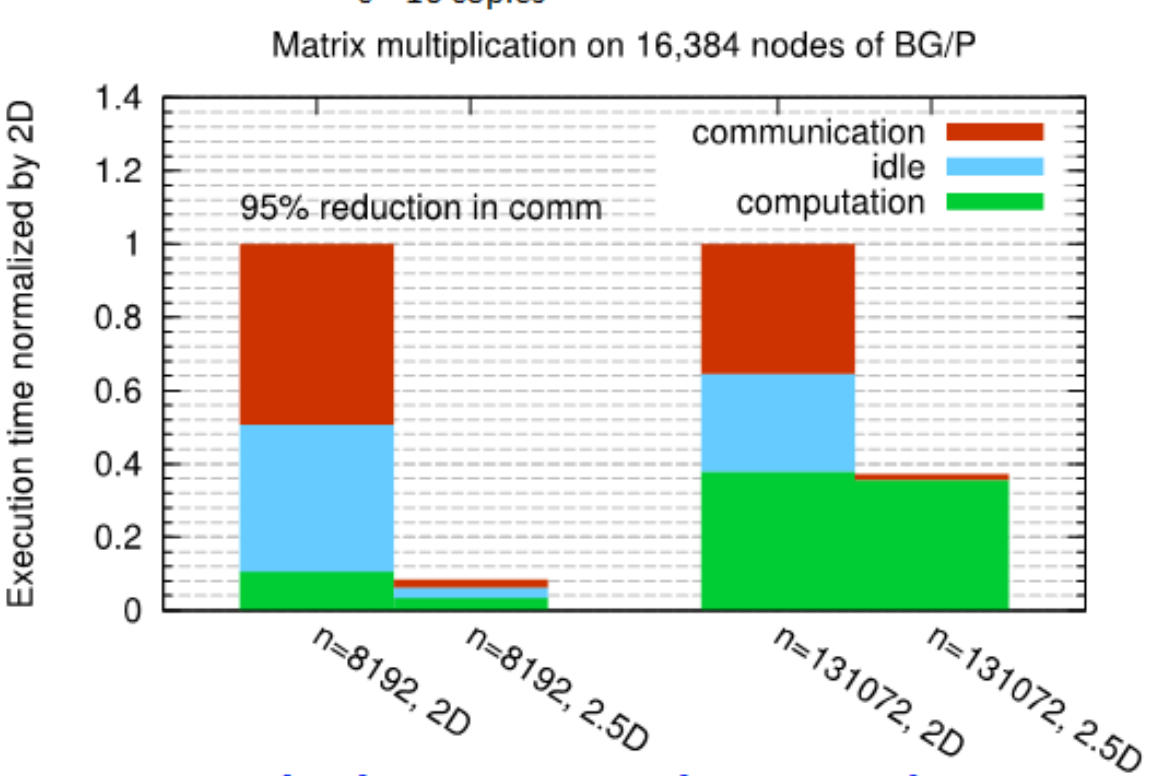
focused on the most productive level.

- [1] R. Brooks, "Towards a theory of the comprehension of computer programs", Int. J. of Man-Machine Studies, vol. 18, pp. 543-554, 1983.
- [3] M. Petre and R.L. Winder, "Issues governing the suitability of programming languages for programming tasks. "People and Computers IV: Proceedings of HCI-88, Cambridge University Press, 1988.
- [4] M. Petre, "Expert Programmers and Programming Languages", in [Hoc90], p. 103, 1990.
- [2] S. P. Robertson and C Yu, "Common cognitive representations of program code across tasks and languages", int. J. Man-machine Studies, vol. 33, pp. 343-360, 1990.

Models that hide Communication and network details are "dead on arrival"

- Jim Demmel's group at UC Berkeley has shown dramatic performance improvements by:
1. Communication avoiding algorithms
2. Algorithms that exploit the details of a computer's network

2.5D Matmul on BG/P, 16K nodes / 64K cores



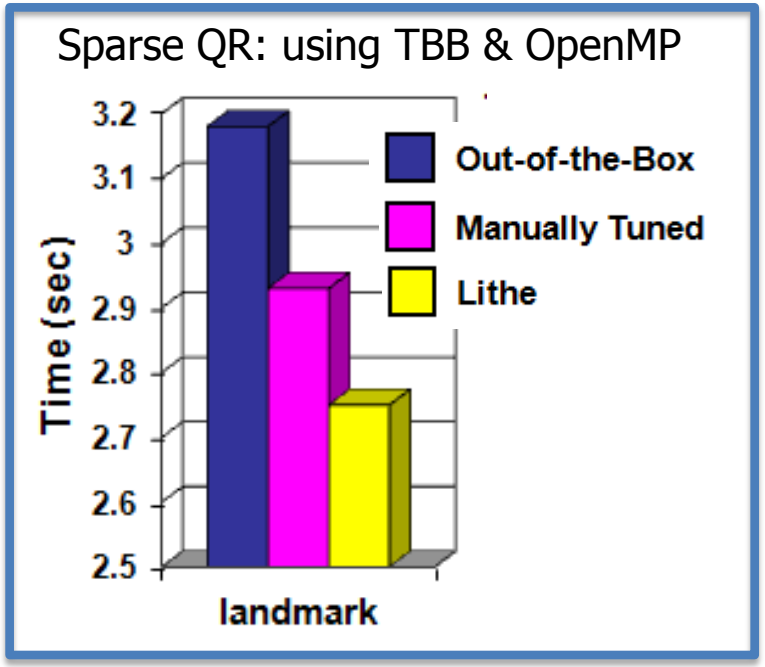
Distinguished Paper Award, EuroPar'11

SC'11 paper by Solomonik, Bhatele, D.

Source: Jim Demmel, UC Berkeley

We spend too much time on the less important problems (programming models)

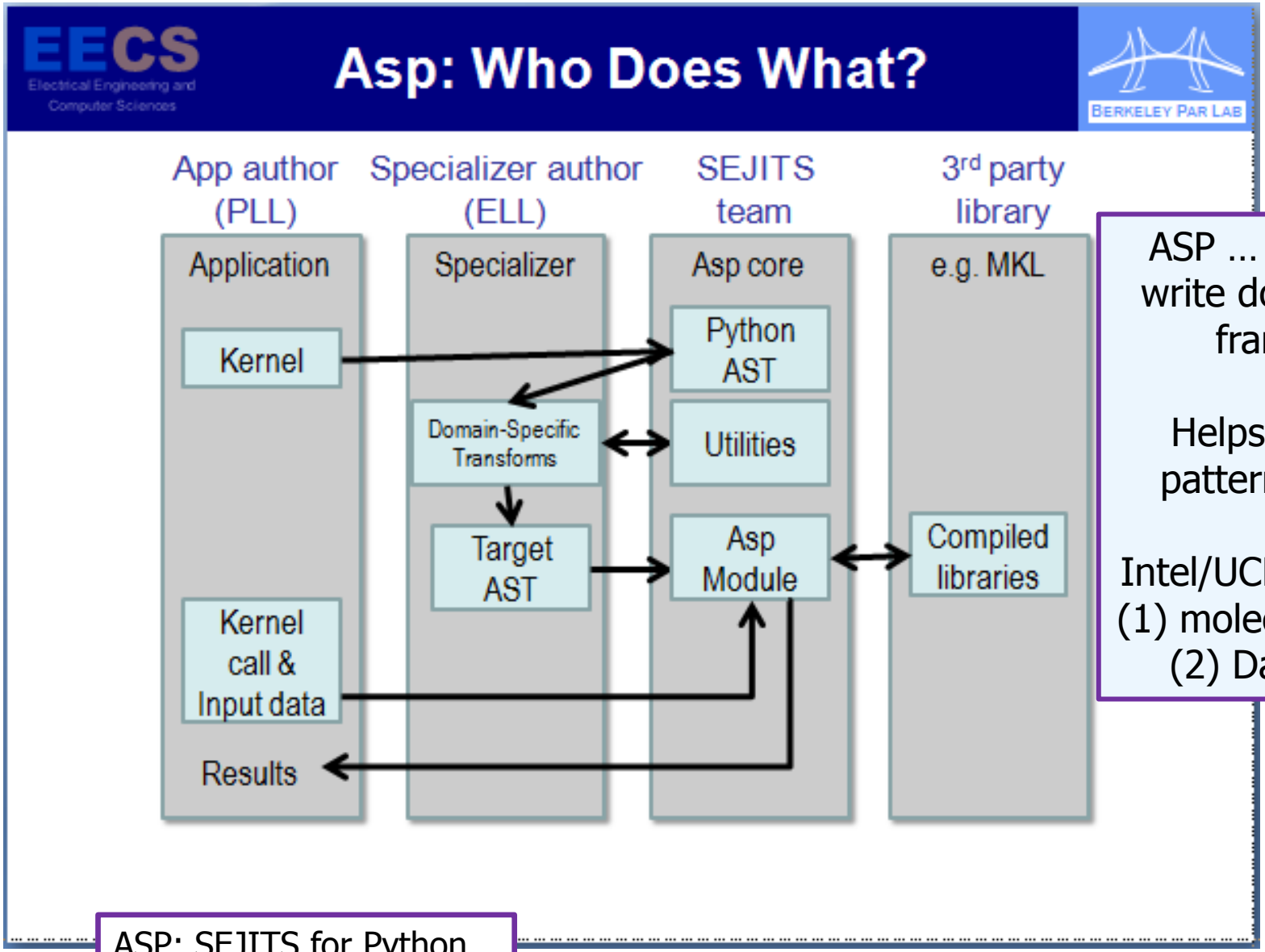
- Modern software engineering stresses modular development by large distributed teams.
  - The Parallel Composition problem … Expose resource management and schedulers to safely mix parallel software modules.
  - Example: Heidi Pan's dissertation from MIT & UC Berkeley.



- There will never be "one programming model" to rule them all ... So lets stop trying to find that ideal model.

- Make the choice of programming model irrelevant by establishing a common Intermediate representation.
- Composition across programming models.
- Example: SPIR project in OpenCL based on LLVM.

Turning Patterns expressed as Python code into high performance parallel code



ASP ... a platform to write domain specific frameworks.

Helps turn design patterns into code.

Intel/UCB test projects:
(1) molecular modeling.
(2) Data analytics

Conclusion

- Put the Human (not the computer first) and create a foundation of parallel computing principles grounded in how programmers think.
- Models at every level must be available to the programmer and provide insights for REAL hardware (consider the success of communication avoiding algorithms).
- The Parallel Composition problem is where the most work is needed:
  - Composition across software modules (e.g. Lithe)
  - Composition across programming models (e.g. SPIR)