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ASCR Programming Challenges Workshop

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Welcome and Goals

- **Welcome**
- **Workshop Goals:**
  - ***Define objective criteria*** for assessing programming models and language features that enable effective use of diverse Exascale architectures for important science applications.
  - ***Prioritize challenges for programming models, languages, compilers and runtime systems for Exascale***
  - ***Prioritize options*** for
    - evolutionary path,
    - revolutionary path and
    - bridging the gap between evolutionary and revolutionary paths
  - ***Create a roadmap***, with options, timeline, and rough cost estimates for programming Exascale systems that are responsive to the needs of applications and to future architectural constraints

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State-of-the-Art Session II

- **Presentations** on compiler and runtime engines that support advanced programming models and languages.
- **Focused Parallel Panel Discussions**
  - **Language Constructs Panel:** Develop objective criteria to assess language constructs in the context of co-designed applications and hardware to execute them.
  - **Compiler and Runtime Engines Panel:** Develop objective criteria to assess compiler and runtime engines to support advanced programming models and language constructs.
  - **Migration Panel:** Develop options to automatically connect/transform/migrate to advanced programming environments
- **General Panel Discussions**

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Challenges to the HPC Community

- **Do Embedded Systems Concurrent Languages have interesting/appealing features for HPC?**
  - Data Flow languages:
    - Synchronous Data Flow
    - Dynamic Data Flow
    - LUSTRE[1] (a synchronous data flow language in which equations uniquely define variables),
    - SIGNAL[2] (another synchronous data flow language in which programs are equations and block diagrams),
    - Esterel[3],
    - Actors[4].

1. Halbwachs, N.; Caspi, P.; Raymond, P.; Pilaud, D. (1991). T*he synchronous data flow programming language LUSTRE*. Proc. IEEE, Volume: 79 Issue:9, pp. 1305 – 1320.
2. Le Guernic, P.; Benveniste, A.; Bournai, P.; Gautier, T.;(1986) . *Signal--A data flow-oriented language for signal processing.* IEEE Trans. Acoustics, Speech, Signal Processing. Volume: 34 Issue:2, pp. 362 – 374
3. Boussinot, F.; de Simone, R. (1991) The ESTEREL Language, Proc. IEEE, Volume: 79 Issue:9 , pp. 1293 - 1304
4. Gul Agha (1986). *Actors: A Model of Concurrent Computation in Distributed Systems*. Doctoral Dissertation. MIT Press).

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Challenges to the HPC Community

- Do Embedded Systems Concurrent Languages have interesting/appealing features for HPC?
  - Control-oriented languages:
    - Event-driven state machines,
    - Statecharts (event-driven model, equivalent to FSMs in expressiveness, but exponentially smaller).
  - Heterogeneous models/languages frameworks
    - Ptolemy,
    - Metropolis,
    - Simulink.

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General Discussion Questions

- How can we enable scientists to focus on their science rather than the fine details of a complex Exascale system?
- Will Exascale applications become a collaborative effort, requiring a hierarchy of developers for the different levels of programming focus.?
- Will programs at a given level of abstraction be optimized without knowledge of how lower layers are implemented?

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General Discussion Questions

- Which novel work on programming languages and compilers is needed in order to enable the mapping of the high level constructs, devised by domain scientists, to the machine optimized constructs?
- What new programming models and language constructs can express fine-grained asynchronous parallelism to achieve performance, programmability, and efficiency in the face of disruptive technology changes while simultaneously meeting the needs of an evolving and increasingly unstructured application base?

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General Discussion Questions

- Programs for Exascale computing should be portable by design ("write-once-run-everywhere") and written to scale across multiple hardware generations. What can be done to ensure that this is the case?
- Programs must be able to exploit massive parallelism and must do so in a way that avoids indeterminacy. Today, only modest parallelism can currently be extracted from programs. What can be dome to make program much more concurrent?