The Layers of CSE Software Sustainability

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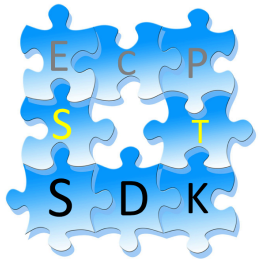

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Software Sustainability Definitions

- Cost Efficient Maintainability and Evolvability
  -- Sehestedt, et al. [1]
- Capacity of the software to endure
  -- Software Sustainability Institute proposal [2]
- The software will continue to be available in the future, on new platforms, meeting new needs
  -- Daniel Katz [3]

Sustainability Factors

How …

extensible
interoperable
maintainable
portable
reusable
scalable
usable

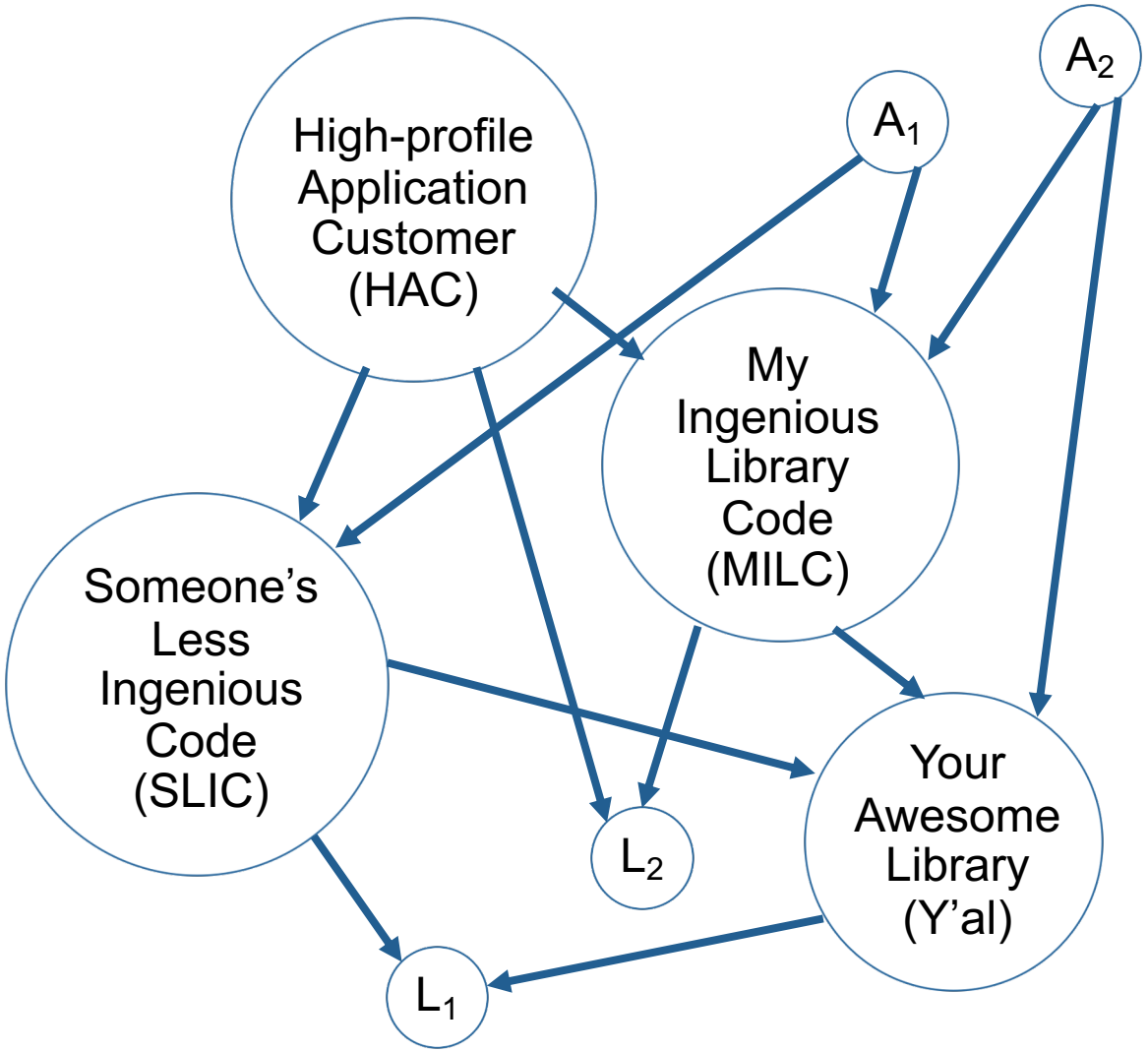
Categories of Software Sustainability

- Intrinsic: Pertaining to characteristics of the software
- Extrinsic: Pertaining to the software development environment

-- Rosado de Souza, et al. [4]

- *Cost Efficient* Maintainability and Evolvability – intrinsic/extrinsic
- *Capacity of the software* to endure - intrinsic
- The software will continue to be available in the future, on new platforms, meeting new needs - neutral

Computational Science and Engineering (CSE) Software Sustainability

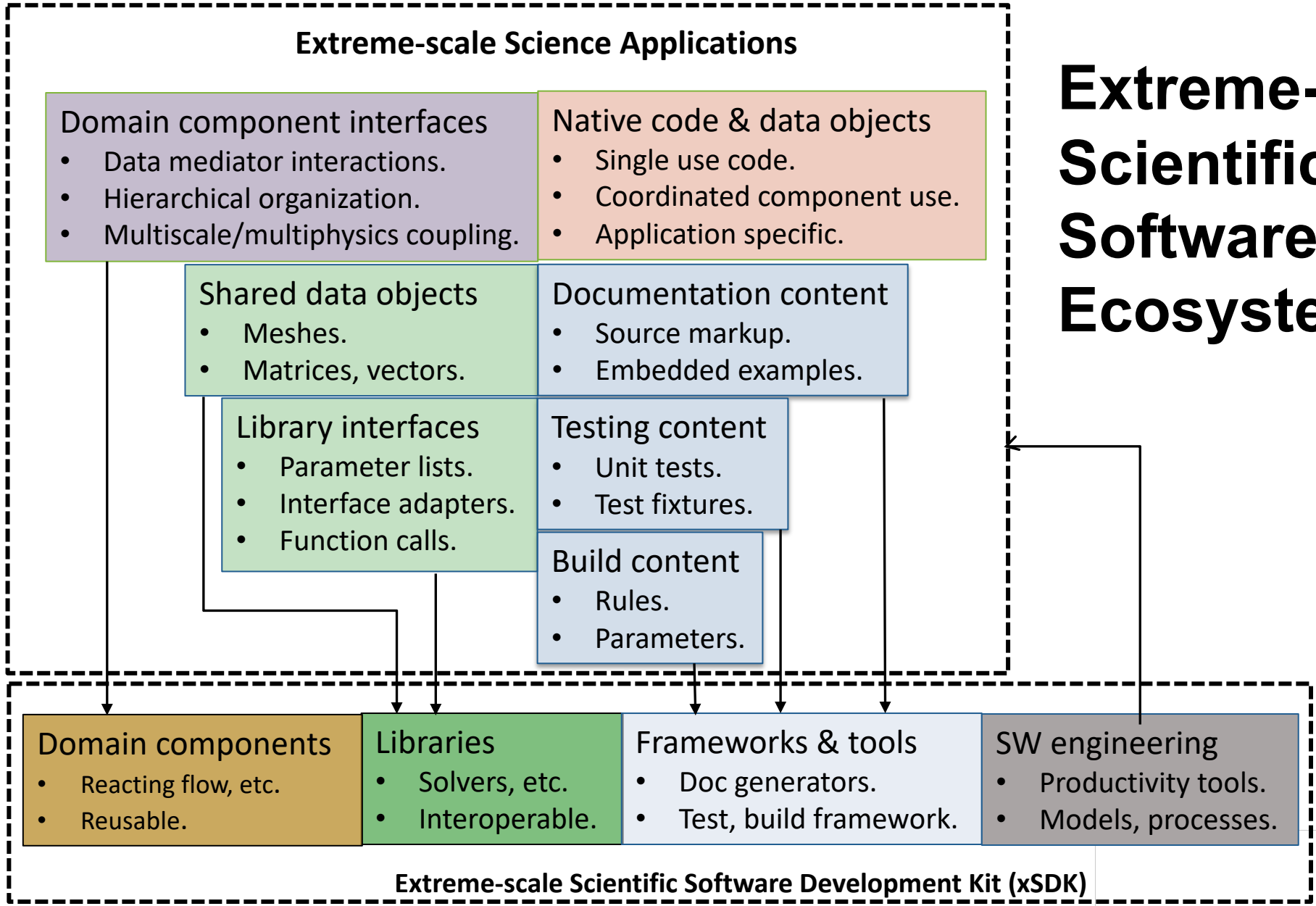


MILC needs to be:

extensible
interoperable
maintainable
portable
reusable
scalable
usable

A quick and dirty proof of concept

Extreme-scale Scientific Software Ecosystem



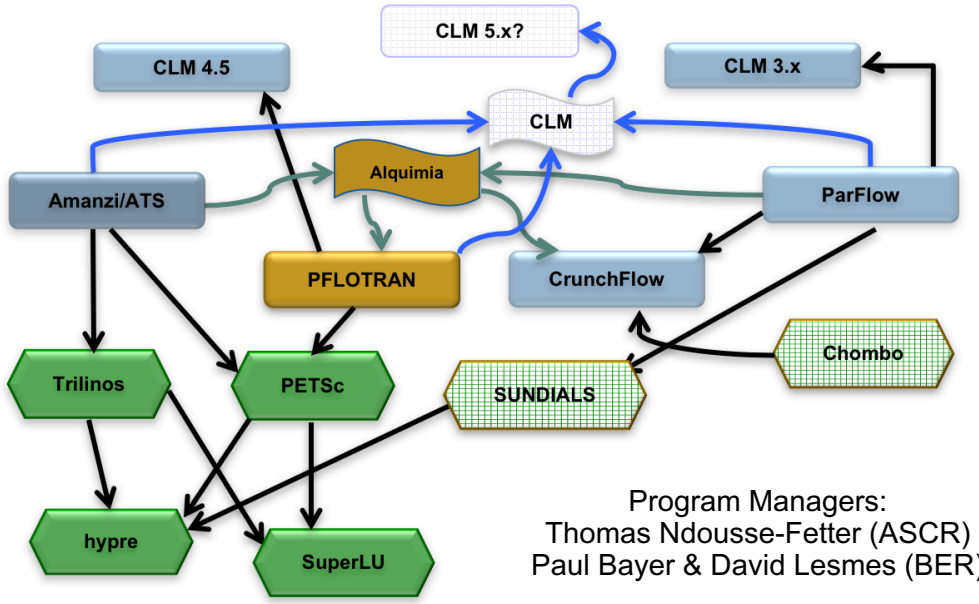
Motivation and history of xSDK

Next-generation scientific simulations require combined use of independent packages

- Installing multiple independent software packages is tedious and error prone
  - Need consistency of compiler (+version, options), 3rd-party packages, etc.
  - Namespace and version conflicts make simultaneous build/link of packages difficult
- Multilayer interoperability among packages requires careful design and sustainable coordination
- **Prior to xSDK effort, could not build required libraries into a single executable due to many incompatibilities**

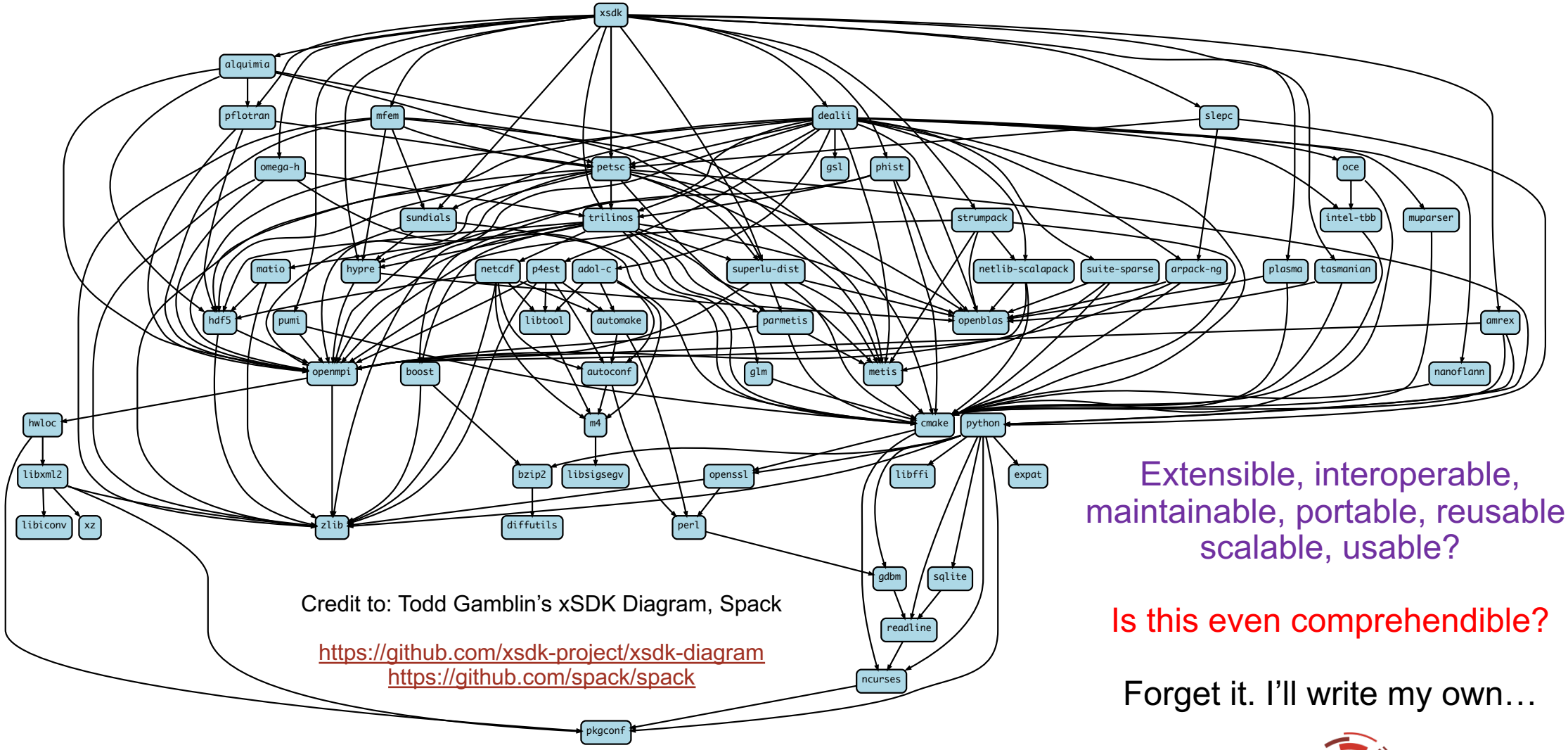
xSDK history: Work began in ASCR/BER partnership, IDEAS project (Sept 2014)

Needed for BER multiscale, multiphysics integrated surface-subsurface hydrology models



Program Managers:
Thomas Ndousse-Fetter (ASCR)
Paul Bayer & David Lesmes (BER)

Complexity of CSE Software Sustainability – the xSDK



Credit to: Todd Gamblin's xSDK Diagram, Spack

https://github.com/xsdk-project/xsdk-diagram
https://github.com/spack/spack

Extensible, interoperable, maintainable, portable, reusable, scalable, usable?

Is this even comprehendible?

Forget it. I'll write my own…

CSE Software Sustainability Break-down

- **Three layers**
  - **First layer**: Those aspects of sustainability relating directly and specifically to the code base and project circumstances, such as staffing, funding, tools, processes, etc.
  - **Second layer:** Sustainability issues related to the (direct and indirect) dependencies of a software project
  - **Third layer:** Concerned with the interoperability of a well-defined ecosystem of software

First Layer of Sustainability – My Project

- Is my project (intrinsically and extrinsically) sustainable?
  - Project team members/leaders typically have a big impact on (but not complete control of) the first layer
    - Software design
    - Software testing
    - Funding
    - Emphasis placed on documentation
    - Coding guidelines
    - Process for committing changes
    - …

1st Layer Metric Categories

- Complexity
- Coupling
- Cohesion
- Size
- Sarkar metrics [5]
- …
- These are useful, but do not capture the complexity of CSE software sustainability

Second Layer of Sustainability – Project Dependencies

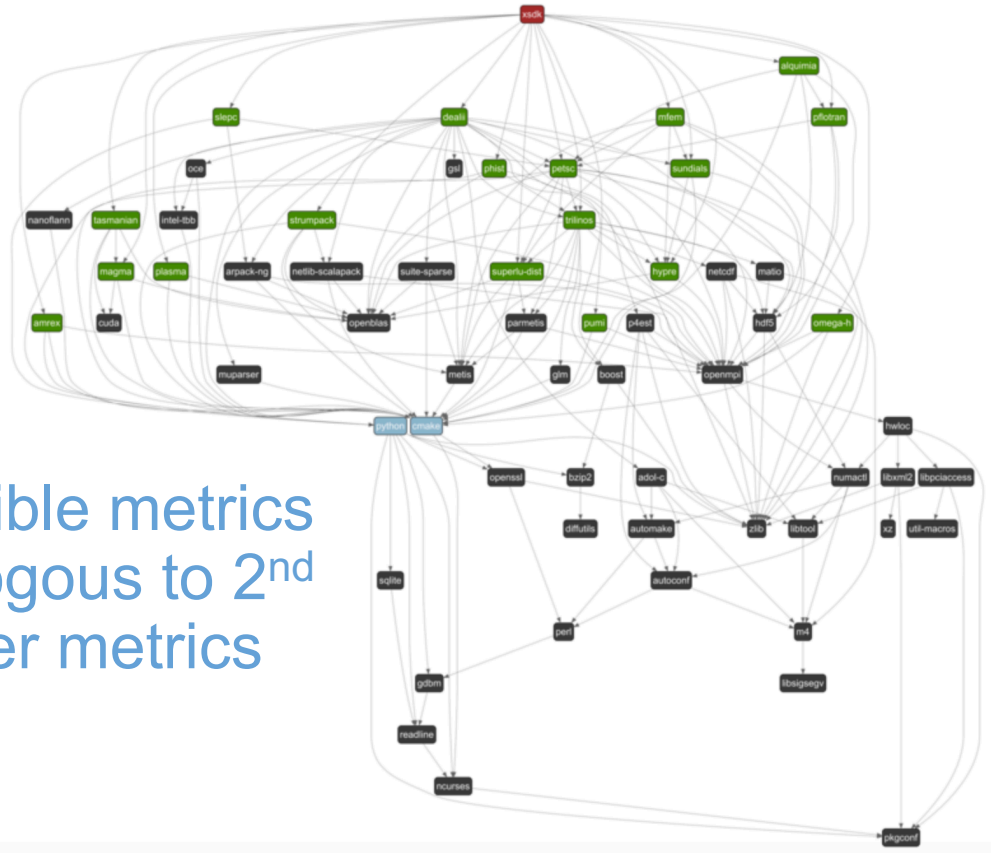
- Can my project “safely” accept a dependence on other pieces of software?
  - Interface stability
  - User support
  - Documentation
  - Funding stability
  - Sustainability of its dependencies
  - “-ability” list
  - …

Possible 2nd Layer Metrics

- What percentage of the CSE-related software dependencies (direct or indirect) for a given software library or application are interoperable with one another and
  - periodically versioned for interoperability? (e.g., through Spack/E4S)
  - regularly tested for continued interoperability? (e.g., through Spack/E4S)
- What percentage of lines of source code of the CSE-related software dependencies (direct or indirect) for a given software library or application are interoperable with one another and
  - periodically versioned for interoperability?
  - regularly tested for continued interoperability?
- What percentage of interface calls to dependency libraries support backward compatibility?
- What percentage of days in the past three months have the dependencies of a given software library or application been interoperable at a development version level?

Third Layer of Sustainability – An Ecosystem of Software

- What set of software products can be used “safely” & interoperably?
  - What packages, features, and interoperability is necessary and useful?
    - Chicken/egg problem
  - Long-term view
- Not all of the software in the ecosystem needs to survive indefinitely
  - Graceful retirement



Possible metrics analogous to 2nd layer metrics

EXASCALE COMPUTING PROJECT

Between the Layers

- Layers feed one another
  - More sustainable packages make for a more sustainable ecosystem
  - Better testing infrastructure and coverage makes it easier to sustain packages
- Need a vocabulary to discuss intricacies of CSE software sustainability.
  - Can these layers or a modified version of them enable those discussions?
- A package that is perfectly first layer sustainable may not be “safe” to use without higher levels of sustainability
  - Unless it depends on no other CSE software, which devastates productivity
  - Higher levels involve a lot of extrinsic factors
- Need ways to quantify sustainability

Sources

- [1] Stephan Sehestedt, Chih-Hong Cheng, and Eric Bouwers. 2014. Towards quantitative metrics for architecture models. In Proceedings of the WICSA 2014 Companion Volume (WICSA '14 Companion). ACM, New York, NY, USA, , Article 5, 4 pages. DOI: http://dx.doi.org/10.1145/2578128.2578226
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- [3] Daniel Katz. 2016. Defining Software Sustainability. Retrieved from https://danielskatzblog.wordpress.com/2016/09/13/defining-software-sustainability/.
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- [5] Santonu Sarkar Avinash C. Kak Girish Maskeri Rama "Metrics for Measuring the Quality of Modularization of Large-Scale Object-Oriented Software" IEEE Transactions on Software Engineering vol. 34 no. 5 Sep–Oct 2008. DOI: 10.1109/TSE.2008.43
- *"Works As Coded." Abbreviations.com.* STANDS4 LLC, 2019. Web. 18 Jul 2019. <https://www.abbreviations.com/Works%20As%20Coded>.