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COMPONENT BASED TOOL FRAMEWORK: CBTF

Krell Institute related tools (O|SS, CBTF, SWAT) Implementation Details, Issues,and Status

CsCADS 2012

Snowbird, Utah

June 26, 2012

LLNL-PRES-503431

Presenters

- **Jim Galarowicz, Krell**

- **Larger team**
  - Don Maghrak, William Hachfeld, Dave Whitney, Dane Gardner: Krell Institute
  - Martin Schulz, Matt Legendre, Chris Chambreau: LLNL
  - David Montoya, TJ Machado, Mike Mason, Jennifer Green, Phil Romero: LANL
  - Mahesh Rajan: SNLs
  - Dyninst group:
    - Bart Miller, UW and team
    - Jeff Hollingsworth, UMD and team
  - Phil Roth: ORNL

Outline

- Introduction

① Open|SpeedShop overview and status

② PTGF (Parallel Tool GUI Framework)

③ SWAT (Scalable Targeted Debugger for Scientific and Commercial Computing)

④ DOE SBIR Heterogeneous Processor support

⑤ Component Based Tool Framework (overview)

⑥ Component Based Tool Framework (tools)

⑦ Next generation: CBTF

- Questions

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COMPONENT BASED TOOL FRAMEWORK: CBTF

Open|SpeedShop

(www.openspeedshop.org)

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Project Overview: What is Open|SpeedShop?

- **What is Open|SpeedShop?**
  - HPC Linux, platform independent application performance tool
  - Works on dynamic and static executables
- **What can Open|SpeedShop do for the user?**
  - pcsamp: Give lightweight overview of where program spends time
  - usertime: Find hot call paths in user program and libraries
  - hwc, hwctime, hwcsamp: Give access to hardware counter event information
  - io, iot: Record calls to POSIX I/O functions, give timing, call paths, and optional info like: bytes read, file names...
  - mpi, mpit: Record calls to MPI functions. give timing, call paths, and optional info like: source, destination ranks, ...
  - fpe: Help pinpoint numerical problem areas by tracking FPE
- **Maps the performance information back to the source and displays source annotated with the performance information.**
- **osspcsamp** "How you run your application outside of O|SS"

Open|SpeedShop

- **Update on status of Open|SpeedShop**
  - Port Open|SpeedShop to Blue Gene Q
    - Available at ANL on vesta, LLNL on rzuseq, and on IBM Rochester xxx
    - Issues with unwinding. Thanks to Matt Legendre for patches to libunwind.
  - More focus on CBTF the past year but, added functionality to O|SS
    - Support for Cray dynamic executables
      - Execute similar to cluster: osspcsamp "how you run your application"
    - Blue Gene P/Q personality support
    - Added more options to compare script (osscompare)
    - Support derived metrics in the CLI through doing arithmetic on perf. data
  - Starting DOE SBIR to research and add performance analysis support for GPU/Accelerators
    - Talk more about this in the DOE SBIR portion of the talk
  - Adding a CBTF component instrumentor for data collection that leverages Lightweight MRNet for scalable data gathering and filtering.
    - Talk more about this in the CBTF portion of talk

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PTGF (Parallel Tools GUI Framework)

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PTGF (Parallel Tools GUI Framework)

- **What is PTGF?**
  - A parallel tools GUI framework developed by Argo Navis* as part of NASA SBIR program written in QT4 toolkit.
  - Integrates parallel tools into common interface
    - Multiple tools already exist or are in-the-works
- **Highlights:**
  - Support for adding tool plugins
    - Initial 'welcome' page
      - Register external web links (tutorials, videos, etc.)
      - Register links to internal help files
      - Register RSS feeds for updated news
    - Register help files for integration into a common interface
    - Register menu actions
  - Data views can be used by all tools
  - Supports 2D and 3D visualizations
  - Annotatable source code viewer
  - Client/server for remote GUI operation

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DOE Small Business Technology Transfer (STTR) SWAT

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SWAT

- **What is SWAT?**
  - A commercialized version of the STAT debugger primarily developed by LLNL/UW (https://computing.llnl.gov/code/STAT)
  - Identify groups of processes in a parallel application that exhibit similar behavior
- **Components used: StackWalkerAPI, MRNet, and PTGF**
- **UW and Argo Navis* teaming together on STTR to:**
  - Port SWAT to more platforms
  - Improve infrastructure
    - Test and extend StackWalkerAPI to work with more compilers, platforms
    - Develop more advanced call tree reduction algorithms
  - Improve interface
    - Enhance the GUI to be more portable, robust, and easy to use
    - Add more support for simplified modes of use
    - Improve SWAT's ability to display complex stack trees

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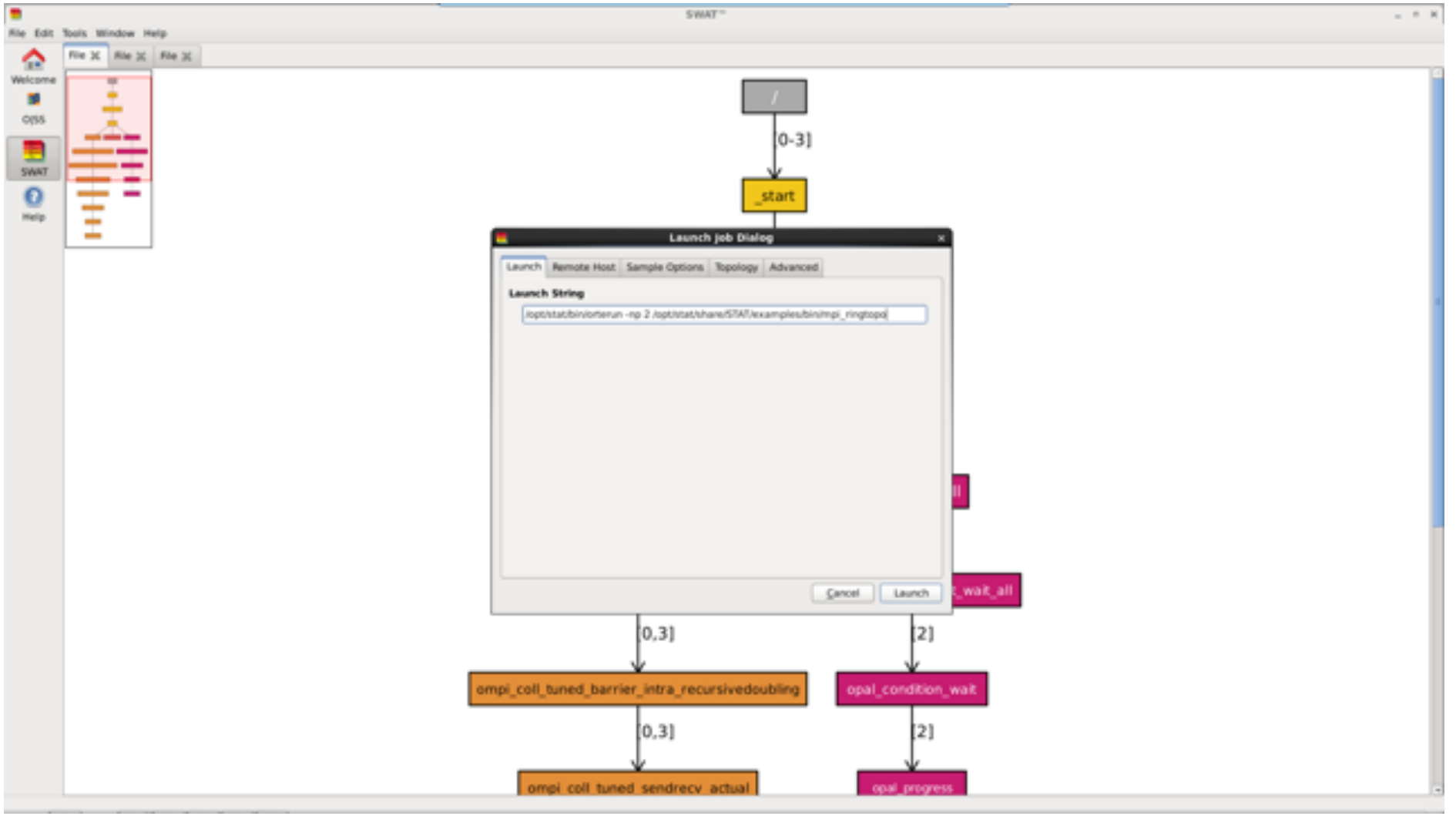
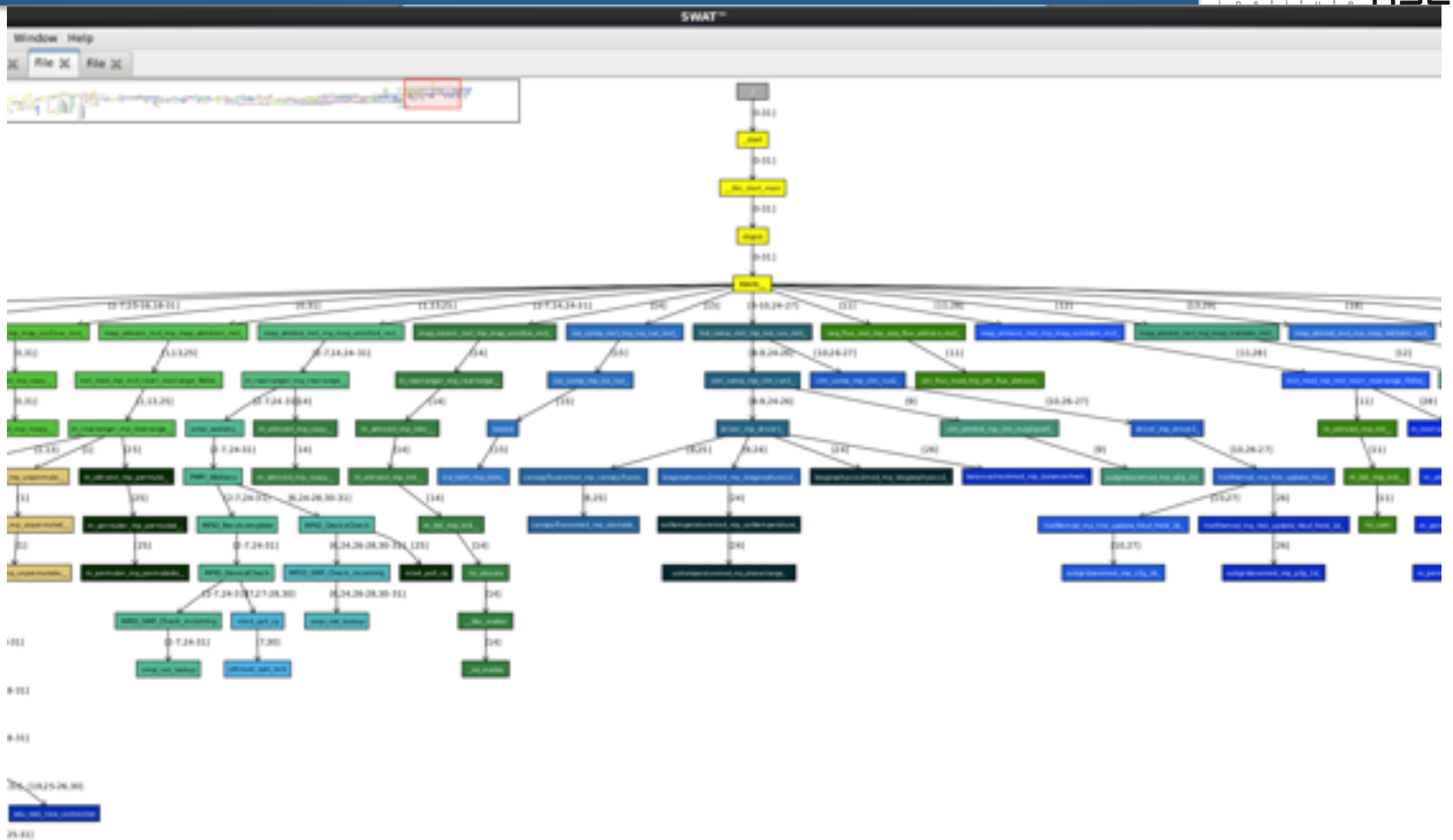
SWAT Early PGTF based GUI View



SWAT Early PGTF based GUI View



*Data used for this rendering courtesy of Greg Lee, LLNL

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COMPONENT BASED TOOL FRAMEWORK: CBTF

DOE **Small Business Innovation Research (SBIR)**

Heterogeneous Processor support

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DOE SBIR Heterogeneous Processor

- **Project goals**
  - Phase I: Investigate and provide proof of concept for adding heterogeneous processor support into Open|SpeedShop
  - Phase II (if awarded):
    - Argo Navis* commercialize GPU support and OpenSpeedShop
    - Finish proof of concept features into a finished product state
- **Research areas:**
  - Tool to identify loops that might be good GPU kernel candidates
  - Reporting time spent in the GPU device (when exited - when entered)
  - Reporting cost and size of data transferred to and from the GPU
  - Reporting information to help the user understand
    - The balance of CPU versus GPU utilization.
    - The balance the transfer of data between the host and device memory with the execution of computational kernels
    - The performance of the internal computational kernel code running on the GPU device
  - Combining other Open|SpeedShop experiment information with GPU info

DOE SBIR Heterogeneous Processor

- **Implementation:**
  - Because we are transitioning to a new scalable tool back-end, we will do all of the accelerator data collection in our Component Based Tool Framework (CBTF) source tree.

- **Discussions this week:**
  - Interested in talking with people about accelerator issues.
    - MIC, NVIDIA, other forms of accelerators and gathering performance information
    - Loop analysis techniques for detecting GPU kernel candidate loops

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COMPONENT BASED TOOL FRAMEWORK: CBTF

Component Based Tool Framework (CBTF)

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CBTF

What is CBTF?

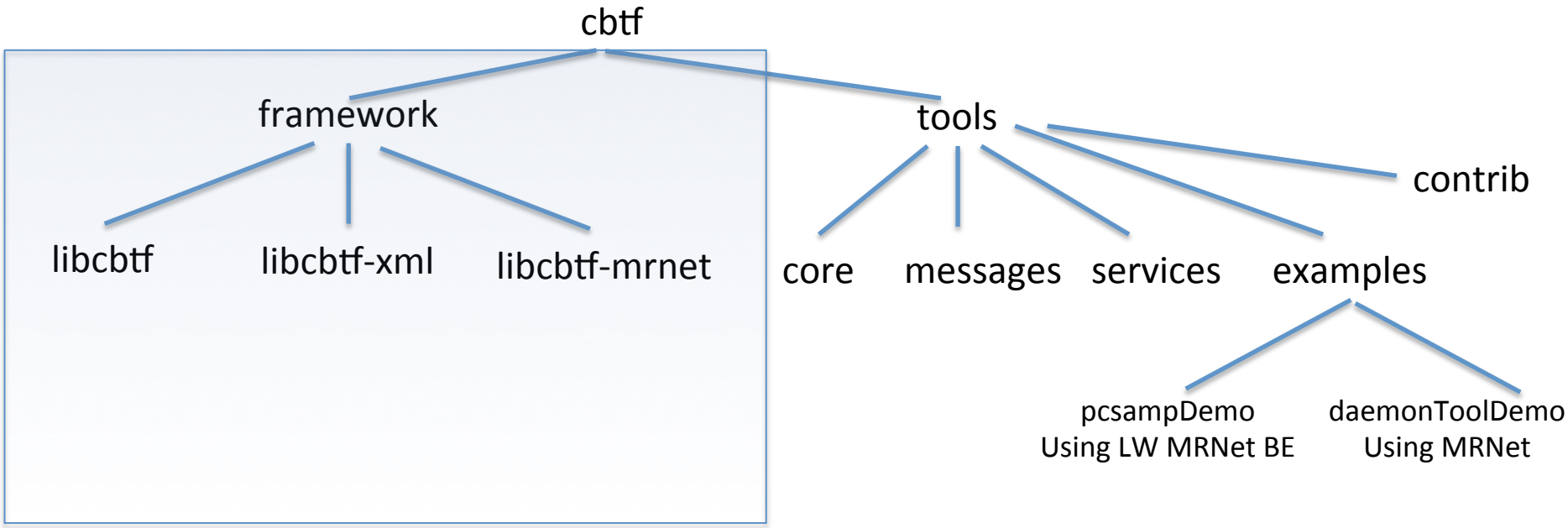
- A Framework for writing Tools that are Based on Components.
- Consists of:
  - Libraries that support the creation of reusable:
    - Components
    - Component networks (single node and distributed)
    - Support connection of the networks.
  - Tool building libraries (partially derived from O|SS)

Benefits of CBTF

- Components are reusable and easily added to new tools.
- With a large component repository new tools can be written quickly with little code.
- Create scalable tools by virtue of a distributed network based on MRNet.
- Components can be shared with other projects

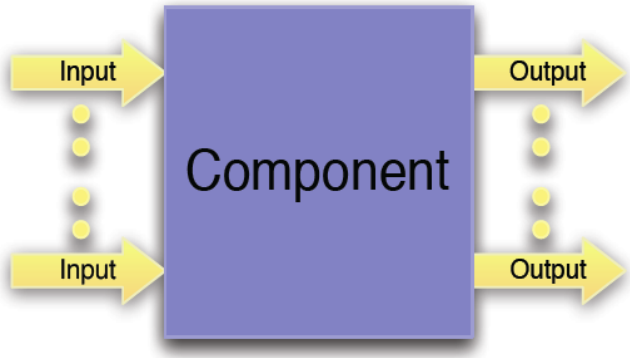
CBTF: Base CBTF Libraries

- **Create components, component networks, distributed component networks**



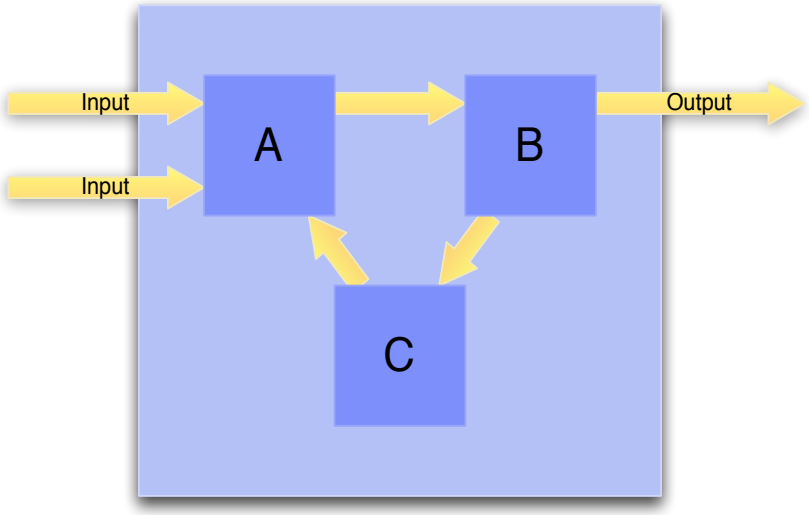
Main concepts: Components

- **Data-Flow Model**
  - Accepts Inputs
  - Performs Processing
  - Emits Outputs



- **Reusable objects with 0-N inputs and 0-M outputs.**
- **Designed to be connected together**
  - Connections defined in C++ or XML file.
- **Components are written in C++**
  - Components can do anything your C++ code can do.
  - Run system commands, open files, do calculations.

CBTF: Component Networks



- **Components**
  - Specific Versions
- **Connections**
  - Matching Input/Output Data Types
- **Arbitrary Component Topology**
  - Pipelines
  - Graphs with cycles
  - ….
- **Recursive**
  - CBTF Component Network is itself a component.
- **XML-Specified Connections**
  - Declare the component connections defining a component network
  - Component version
  - Input/Output types and names

XML File

- **Simple way to build the CBTF networks and connect the components.**
  - No need to recompile (if the available components provide the capabilities needed).

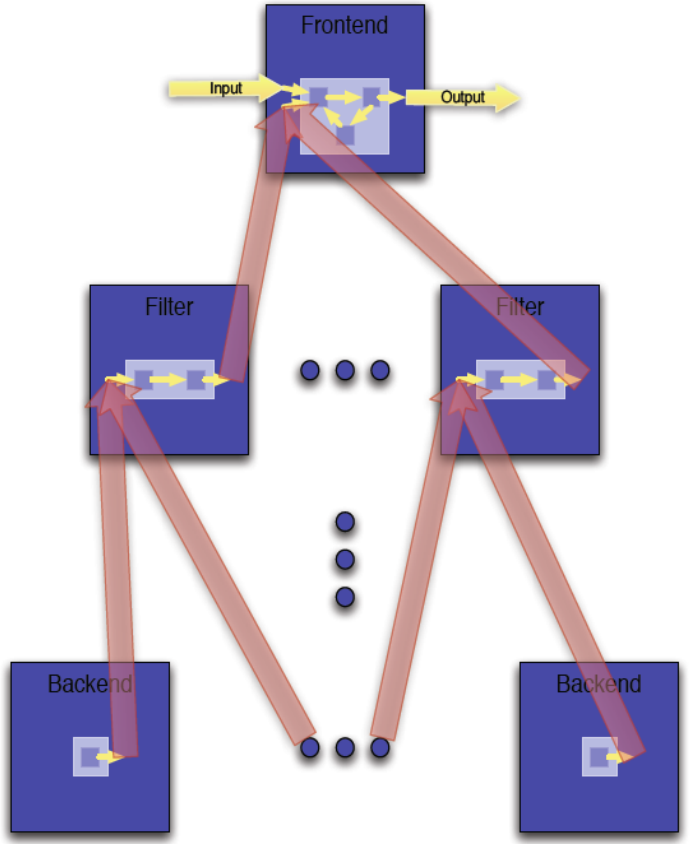
```
<Network xmlns=http://www.krellinst.org/CBTF/Network>
 <Type>TestXML</Type>
 <Version>1.2.3</Version>
 <Plugin>plugin-xml.so</Plugin>

 <Component>
  <Name>Stage1</Name>
  <Type>Doubler</Type>
 </Component>

 <Component>
  <Name>Stage2</Name>
  <Type>Incrementer</Type>
 </Component>

 <Component>
  <Name>Stage3</Name>
  <Type>Doubler</Type>
  <Version minimum="0.0.1" maximum="0.0.5"/>
 </Component>
<Input>
  <Name>in</Name>
  <To>
   <Name>Stage1</Name>
   <Input>in</Input>
  </To>
 </Input>
 <Connection>
 <From>
  <Name>Stage1</Name>
  <Output>out</Output>
 </From>
 <To>
  <Name>Stage2</Name>
  <Input>in</Input>
 </To>
</Connection>
<Connection>
 <From>
  <Name>Stage2</Name>
  <Output>out</Output>
 </From>
 <To>
  <Name>Stage3</Name>
  <Input>in</Input>
 </To>
</Connection>
<Output>
 <Name>out</Name>
 <From>
  <Name>Stage3</Name>
  <Output>out</Output>
 </From>
</Output>
</Network>
```

MRNet

- **CBTF uses a transport mechanism to handle all of its communications.**
- **Currently that transport mechanism is MRNet**
  - Multicast/Reduction Network
  - Scalable tree structure
  - Hierarchical on-line data aggregation
- **CBTF views MRNet as just another component.**
  - In the future it could be swapped with some other transport mechanism, if desired.

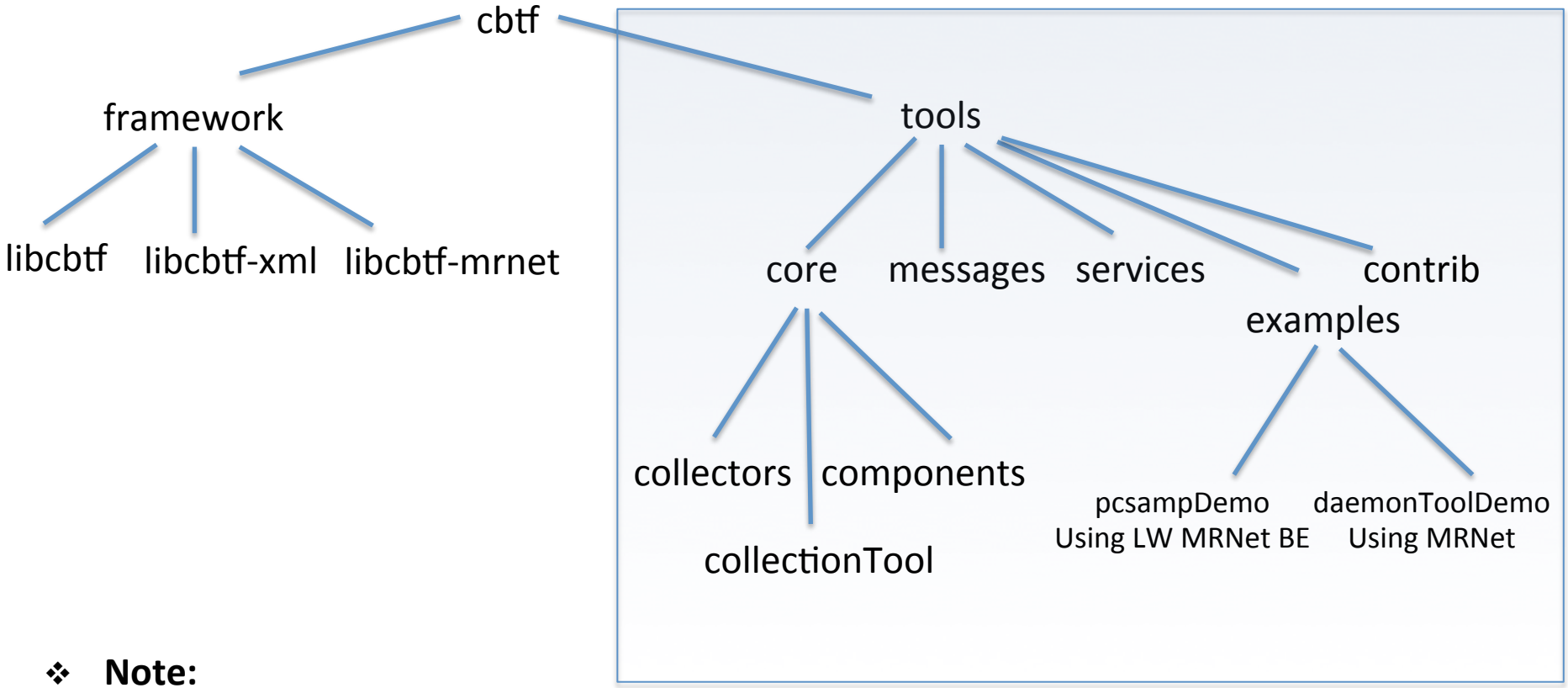
CBTF Networks

- **Three Networks where components can be connected**
  - Frontend, Backend, Multiple communication process levels
  - Every level is homogeneous
- **Each Network also has some number of inputs and outputs.**
- **Any component network can be run on any level, but logically**
  - Frontend component network
    - Interact with or Display info to the user
  - Communication Process Network
    - Filter or Aggregate info from below
    - Make decisions about what is sent up or down the tree
  - Backend component network
    - Real work of the tool (extracting information)



CBTF: Tool Building Support

- **To enable tool builders to get started**
  - Add a tool building side to CBTF (tools subdirectory under cbtf)



- **Note:**
  - daemonToolDemo doesn't rely on any service, message, or core "tools" code
  - collectionTool is a test tool that can be used to test the collectors

CBTF: Software Stack (Tools)

- **Open|SpeedShop**
  - Using Services, Messages, Core built using CBTF infrastructure
  - Create CBTF instrumentor class in O|SS to interface with CBTF
  - Full fledged multipurpose performance tool
  - Scalability…..
    - Allow filtering of performance data as it moves from the application to the client tool
    - Eliminates the current method which writes temporary files to disk.
      - New method does not write files
- **Customized Tools**
  - Use the CBTF infrastructure, not necessarily any support from the ***tools*** support sub-directories
  - If tool creator sees a useful service in ***tools***, they can choose to use it (along with any message and/or core library)
  - Aimed at specific tool needs determined by application code teams

Using CBTF Beyond O|SS

- **Sysadmin Tools**
  - Poll information on a large number of nodes
  - Run commands or manipulate files on the backends
  - Make decisions at the filter level to reduce output or interaction
- **Performance Analysis and Debugger Tools**
  - Massively parallel applications need scalable tools
  - Have components running along side the application
  - Use cluster analysis to reduce thousands (or more) processes into a small number of groups
- **Customized Tools in development:**
  - LANL
    - Sysadmin Tools
      - psTool – run commands on BE processes and transmit, filter on way to client
      - Tbon-FS – perform group file operations
    - Memory analysis tool – displays memory usage information
    - Debugging – stack trace gathering and like trace grouping
    - GPU double bit monitoring tool
  - ORNL
    - GPU monitoring tool
  - UMD
    - Active Harmony integration

CBTF Next Steps

- **Next steps related to CBTF development**
  - **Support:** Active Harmony integration
  - **Support:** Other CBTF tool developments
  - **Provide:** More detailed documentation of examples, demo tools
  - **Investigate and integrate:** tool start up (launchmon, libi, …)
    - Variations dependent on platform type (BG, Cray)
  - **Continue:** Adding tool services, messages, component creation to support more types of collection
    - Not all O|SS collectors have been converted to cbtf/tools
  - **Continue:** Porting to Cray and Blue Gene platforms
  - **Develop:** More filtering components for MRNet communication node deployment
  - **Continue:** The effort to integrate/connect CBTF to O|SS

CBTF Related Discussion Items

Discussions this week:

- Tool start-up and node allocation issues related to running with MRNet
  - Need extra nodes to not impact the application execution
    - Or co-locate communication processes with application
  - Can we get support from the system administrators when users request node allocations?
  - Automatic topology generation
- Installation of needed packages for tools. Can we as a community create a development tools root that would contain packages we all could use for building our tools?
- If any interest, discussions with people about using CBTF to create tools

CBTF Information

- **Where to find information**
  - CBTF wiki: http://ft.ornl.gov/doku/cbtfw/start
- **Source Access**
  - Source hosted at ORNL git repository
  - In process of opening up source – need to move repository to do that
- **CBTF Tutorial, Step by Step Instructional Info on CBTF wiki**
- **LANL: CBTF user guide (in progress)**
- **Always looking to collaborate with others, please contact us**

Questions

- **Jim Galarowicz**
  - jeg@krellinst.org
- **Don Maghrak**
  - dpm@krellinst.org
- **Questions about Open|SpeedShop or CBTF**
  - oss-questions@openspeedshop.org