A decorative graphic on the left side of the slide consists of numerous circles of various sizes and colors, including green, cyan, blue, purple, and magenta, arranged in a pattern that suggests movement or data points.

# SEEING IS UNDERSTANDING: DEBUGGING WITH THE MULTICORE VISUALIZER

EclipseCon 2012

William R. Swanson  
Marc Khouzam

# ABOUT US

---

## > William R. Swanson

- Lead IDE Developer, Tiler Corporation
- CDT Committer, developed Visualizer framework and UI
- 22 years in parallel hardware, software & developer UI tools

## > Marc Khouzam (@marckhouzam)

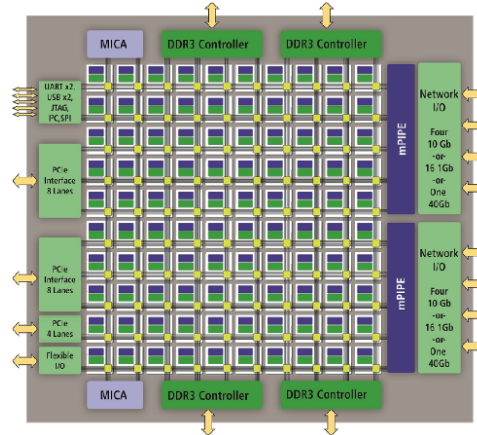
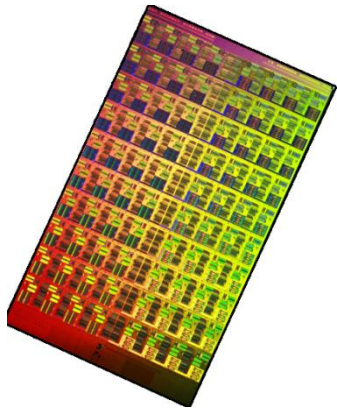
- Lead CDT developer, Ericsson
- CDT Committer, lead of Debug component (DSF-GDB)
- 15 years in Telecom:
  - > Multicore chips
  - > Multi CPU boards
  - > Multi board nodes
  - > Need better tools!

# AGENDA

---

- › The Challenge of Multicore
- › An Answer: Visualization
- › The Multicore Visualizer & Framework (demo)
- › Extending the Visualizer (demo)
- › The CDT Multicore Debug Workgroup
- › Current Projects, Future Plans
  
- › After the talk: demo on 24-core machine.

# MULTICORE SYSTEMS



**Tiler 100-core Tile-GX**

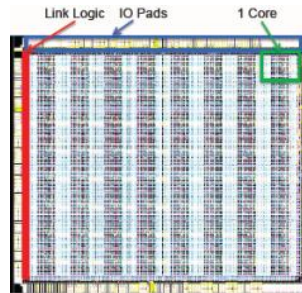
**Ambric's 336-core Am2045**

**Plurality's 256-core Hypercore**

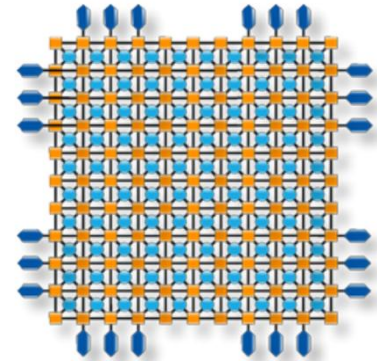
**Intel's 80-core Teraflop**

**ClearSpeed 192-core CSX700**

**AOCS 128-core ModemX**



**Adapteva 64-core Epiphany**



**Coherent Logix' 100-core HyperX**

# MULTICORE SCALABILITY



Debug elements exploding

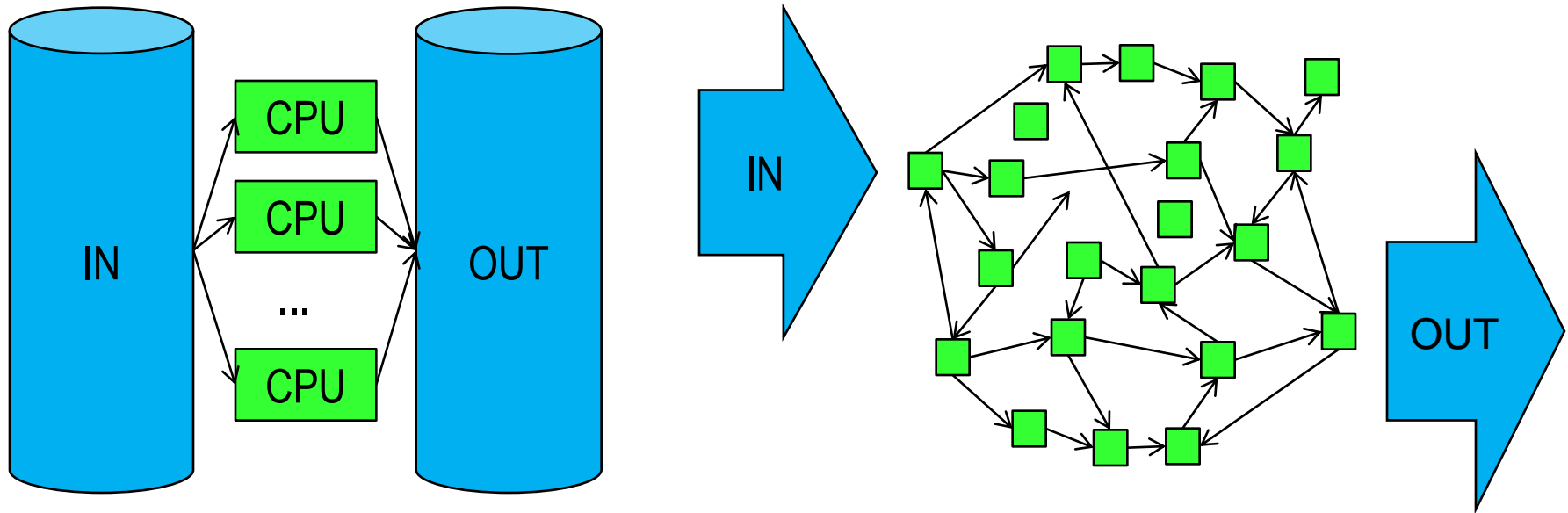
- 100s of cores
- 100s of processes
- 1000s of threads

Can be a literal  
embarrassment of riches...

How to view and control on  
that scale?

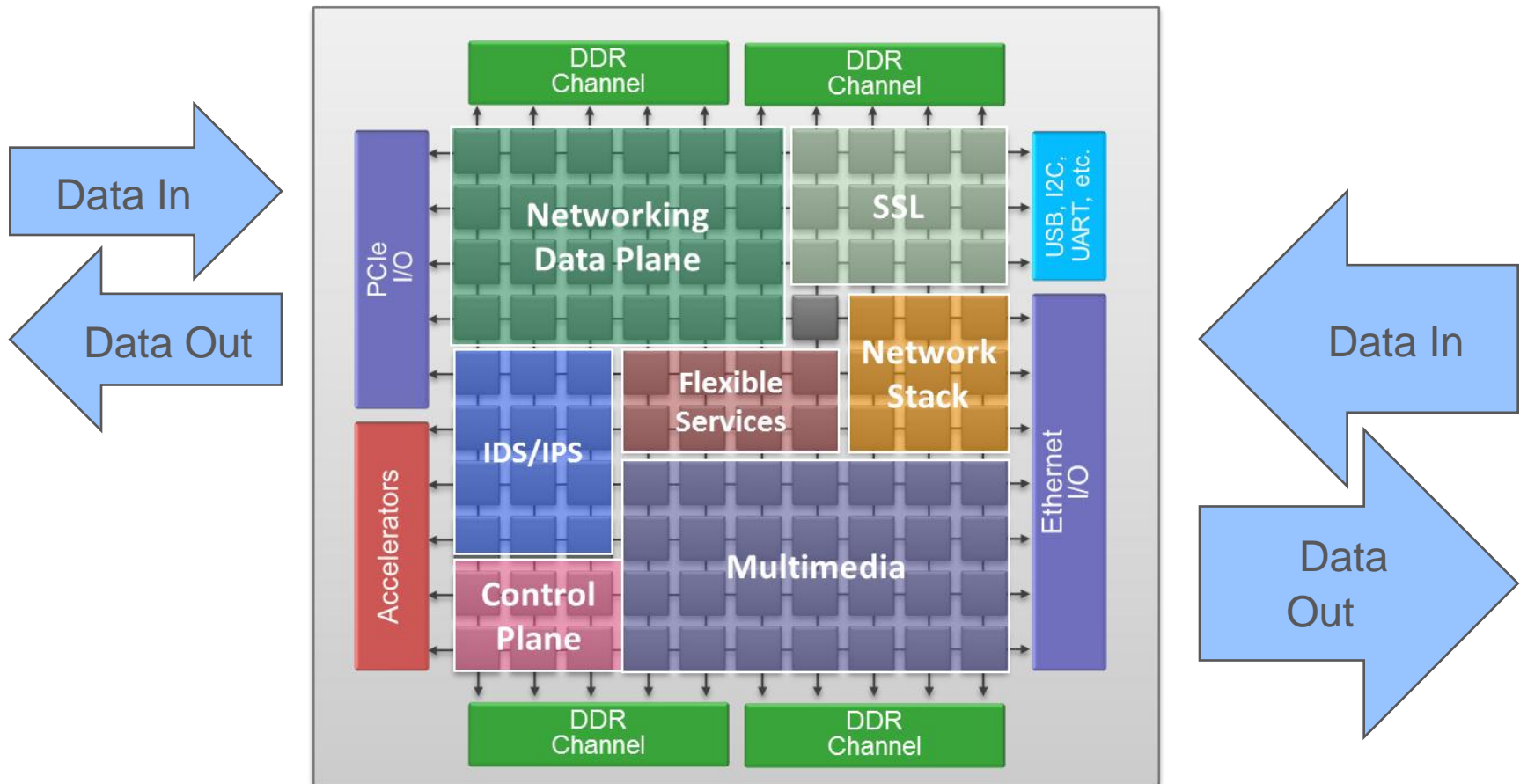
# THE MULTICORE CHALLENGE

- › We're in “big data” era, moving to “big algorithm” era
  - lots of processes/threads, complex interactions
  - ever-increasing need for a “big picture” overview



# EXAMPLE: TILERA PROCESSOR

Distinct pipeline stages or modes can run on different tiles, can also re-affinitize dynamically to help load-balancing.



# EXAMPLE: TILERA PROCESSOR

---

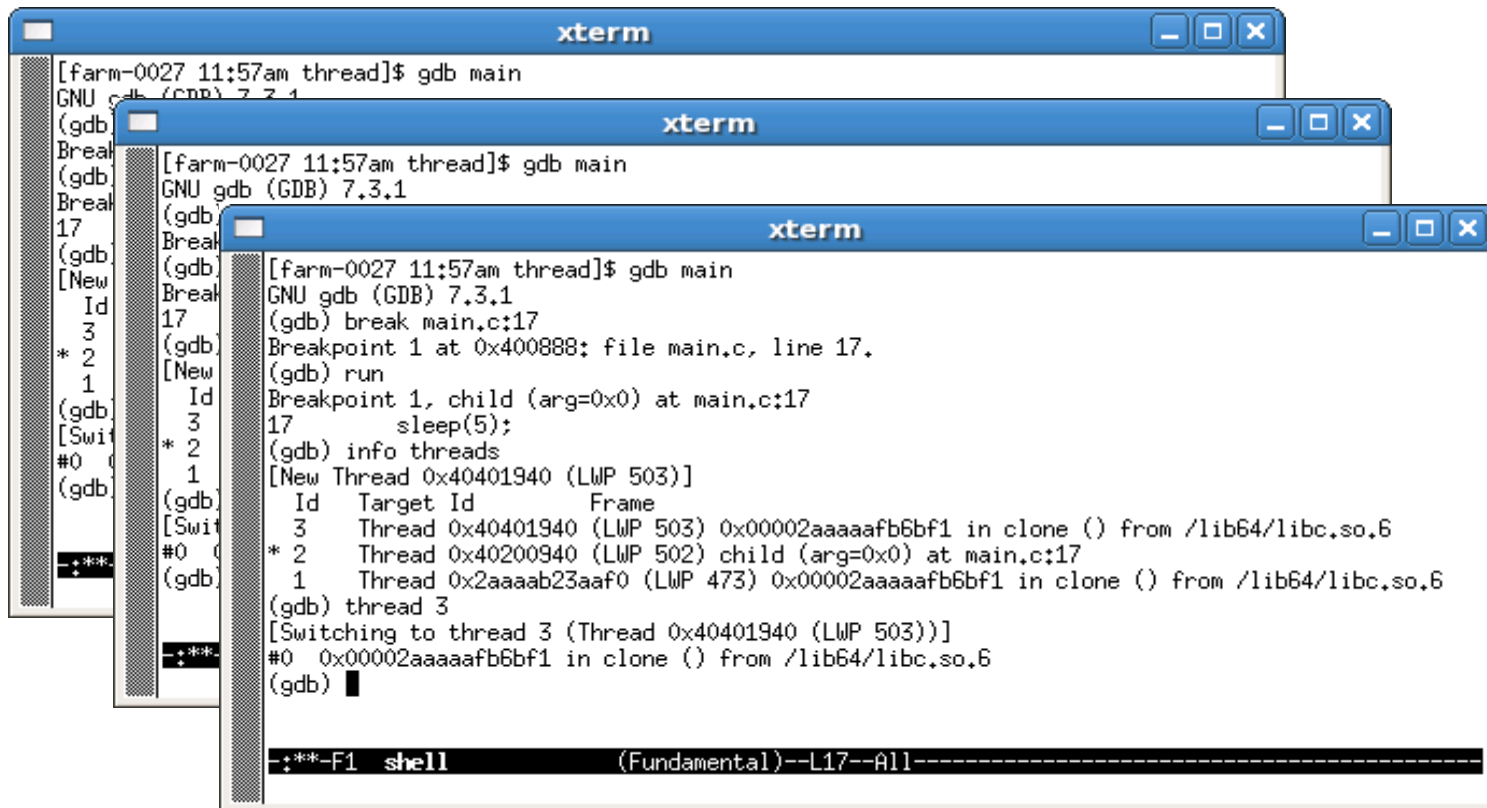
- › And this is ~100 cores!
- › Imagine debugging CPUs / GPUs with 100's or 1000's of cores...
- › where the app is NOT data-parallel or lock-step SIMD!
  
- › We're going to need better tools to handle this!



# CURRENT TOOLS DON'T SCALE

## › Command-line GDB

- multiple shells, even for only a few processes, or
- for multithreaded GDB, having to remember which thread you're on



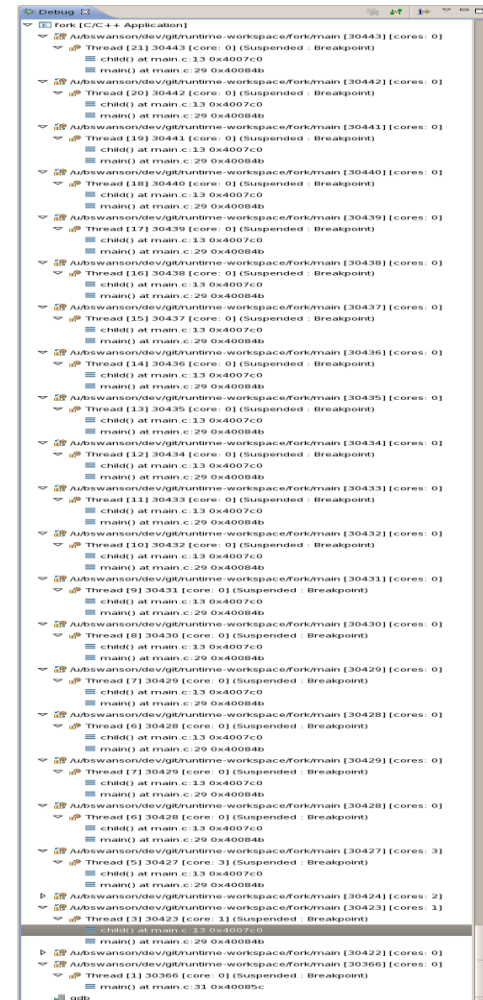
```

[farm-0027 11:57am thread]$ gdb main
GNU gdb (GDB) 7.3.1
(gdb) Breakpoint 1 at 0x400888: file main.c, line 17.
(gdb) run
Breakpoint 1, child (arg=0x0) at main.c:17
   17      sleep(5);
(gdb) info threads
[New Thread 0x40401940 (LWP 503)]
   Id Target Id Frame
   3  Thread 0x40401940 (LWP 503) 0x00002aaaaafb6bf1 in clone () from /lib64/libc.so.6
* 2  Thread 0x40200940 (LWP 502) child (arg=0x0) at main.c:17
   1  Thread 0x2aaaab23aaf0 (LWP 473) 0x00002aaaaafb6bf1 in clone () from /lib64/libc.so.6
(gdb) thread 3
[Switching to thread 3 (Thread 0x40401940 (LWP 503))]
#0 0x00002aaaaafb6bf1 in clone () from /lib64/libc.so.6
(gdb)
  
```

# CURRENT TOOLS DON'T SCALE

## › Eclipse's Debug View

- way better for managing large numbers of processes/threads
- but...
- for big apps, essentially a flat list
- too much repetitive detail
- can't easily see overall layout/behavior
- difficult to find and interact with "important" processes/threads...
- (like this one) ----->



# THE BIG PICTURE: VISUALIZATION

---

- › Need for new ways of looking at applications...
- › One answer: visualization tools
- › Visualization is the “big picture”: the important stuff made easily visible.
  
- › *What this means is that we shouldn't abbreviate the truth but rather get a new method of presentation.*

[Edward Tufte](#)

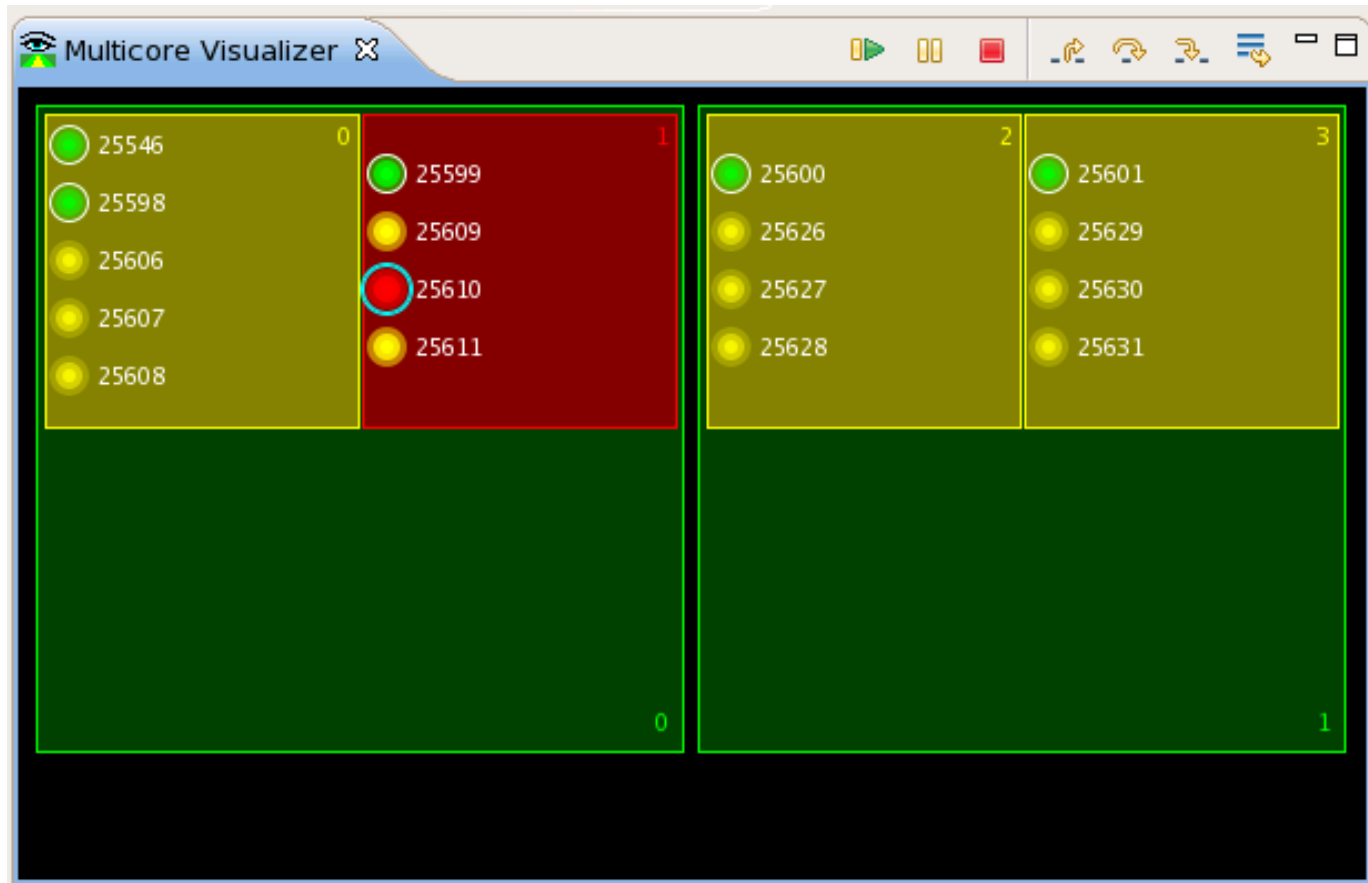
# A VISUALIZATION FRAMEWORK

---

- › There's also a need for a framework
- › Rather than having everyone recreate the wheel, we need a platform to support visualization
- › In the Eclipse spirit it should be flexible and extensible
- › Should handle boilerplate code:
  - view/workbench interaction
  - selection
  - toolbars and context menus
- › Visualizations should be able to focus on presentation.

# THE MULTICORE VISUALIZER

- › New feature, currently optional
- › Being added to CDT in Juno.



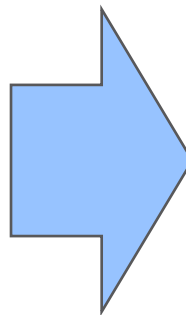
# THE MULTICORE VISUALIZER

- › Visualizer presents an overview of application debug state
- › Doesn't *replace* the Debug View, it *augments* it
- › Analogy: adding pictures to a journal article.
  - Pictures don't replace the text, instead they provide high-level context that makes it easier to parse the details.

When in the Course of human events it becomes necessary for one people to dissolve the political bands which have connected them with another and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. — That to secure these rights, Governments are instituted among Men, deriving their

just powers from the consent of the governed, — That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness. Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn that mankind are more disposed to suffer, while evils are sufferable than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object

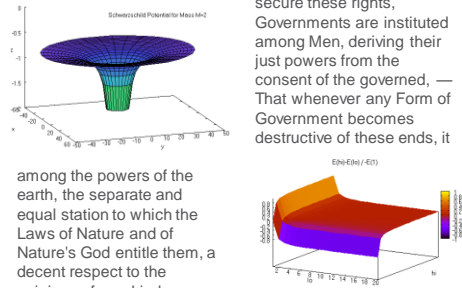


When in the Course of human events it becomes necessary for one people to dissolve the political bands which have connected them with another and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.

We hold these truths to be self-evident, that all men are created equal, that they

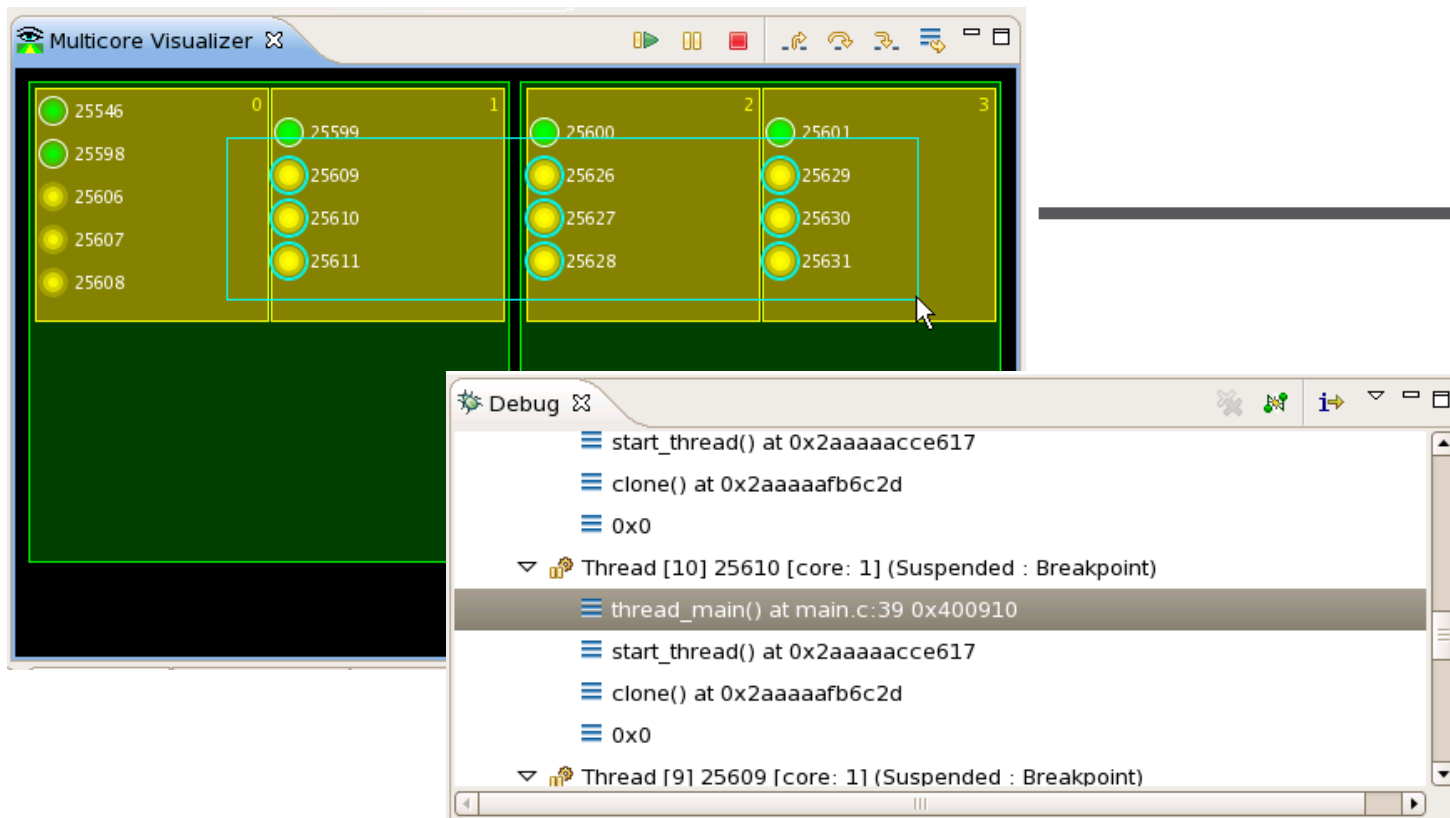
are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. — That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, — That whenever any Form of Government becomes destructive of these ends, it

is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall



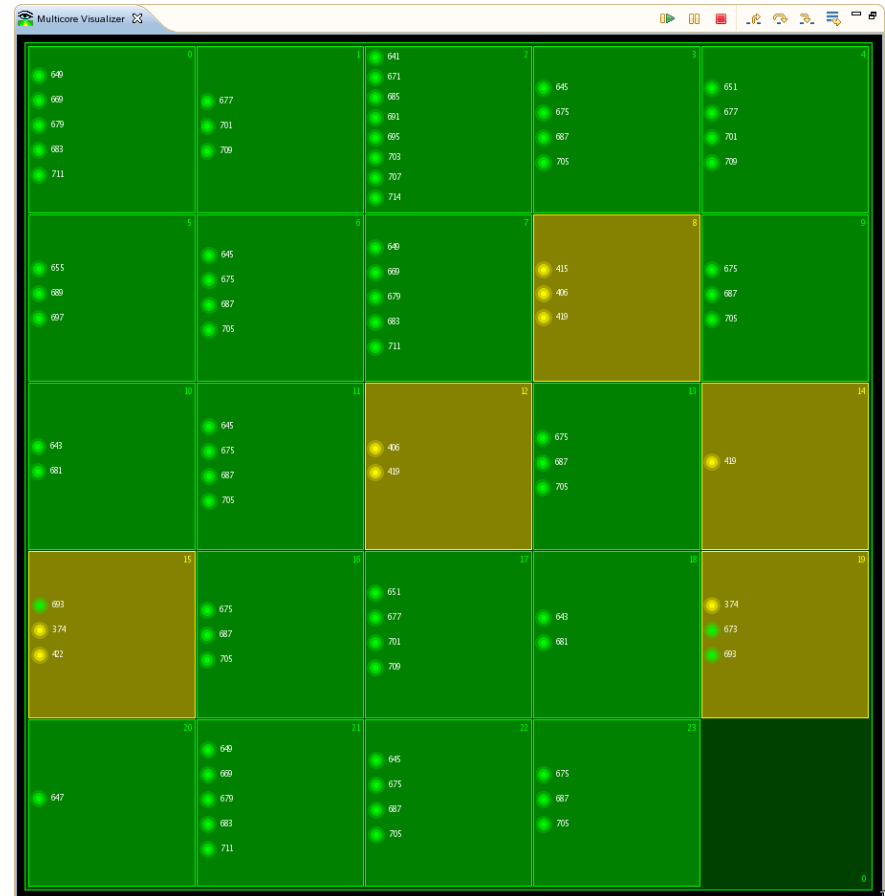
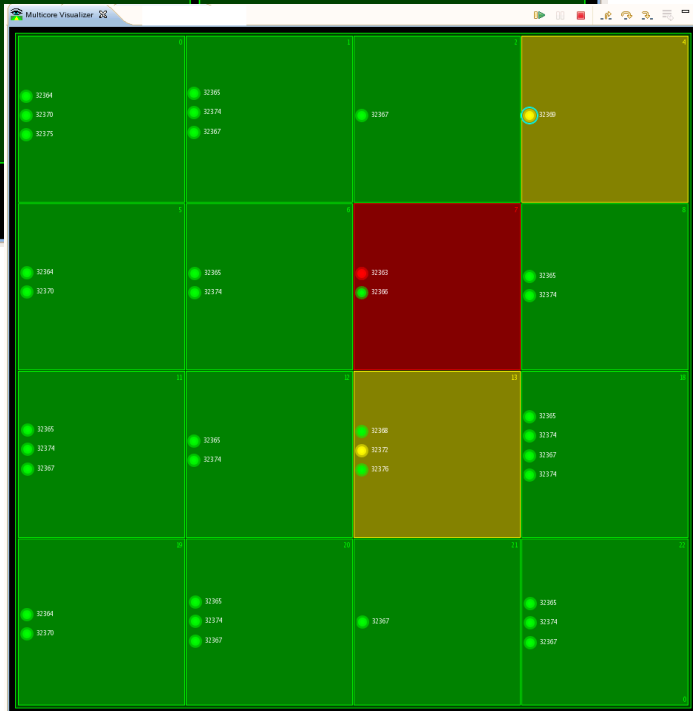
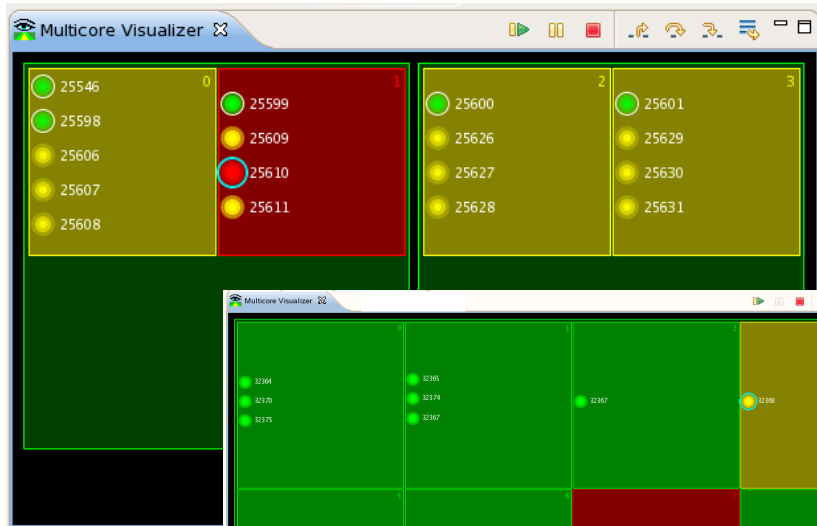
# THE MULTICORE VISUALIZER

- › Visualizer is interactive – can select & interact with program elements (cores, processes, threads)
- › Can still use Debug View to get more detail



# THE MULTICORE VISUALIZER

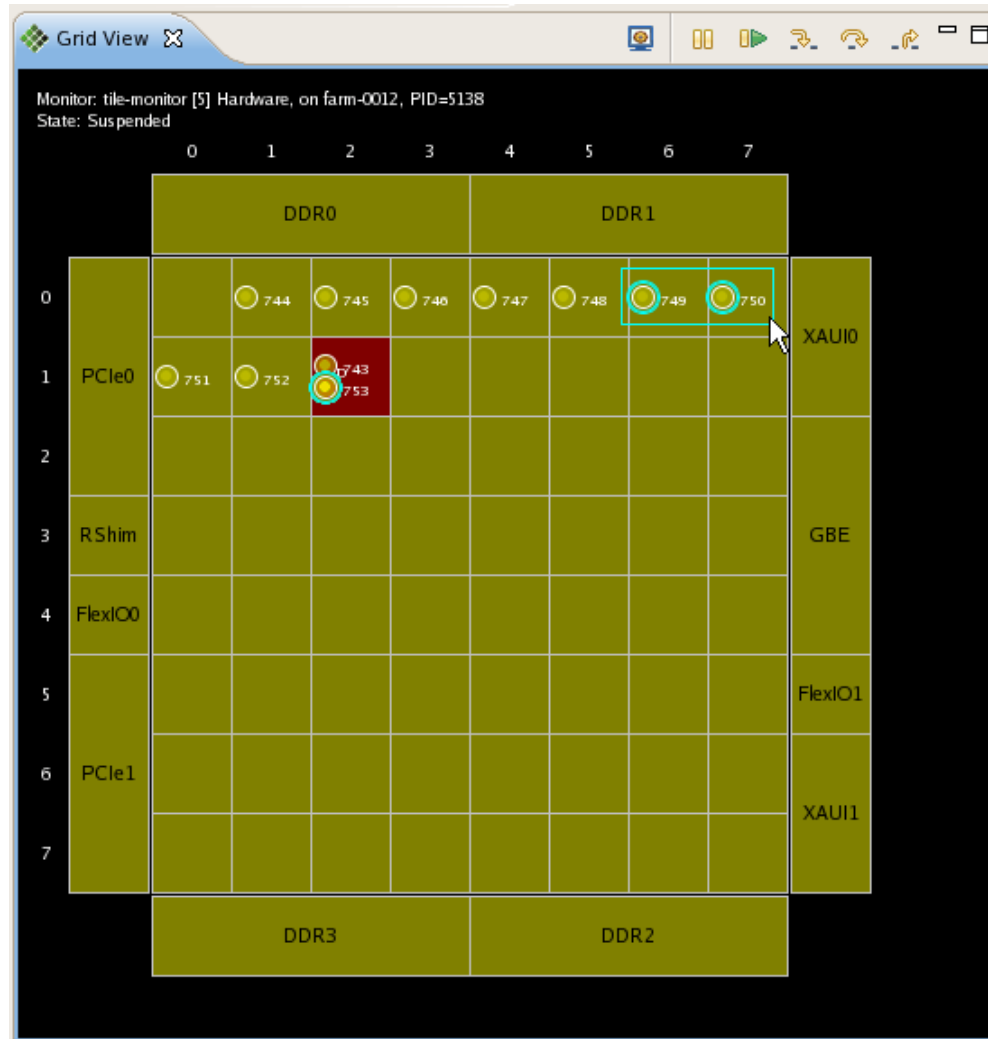
Visualizer display scales to different cpu/core layouts:





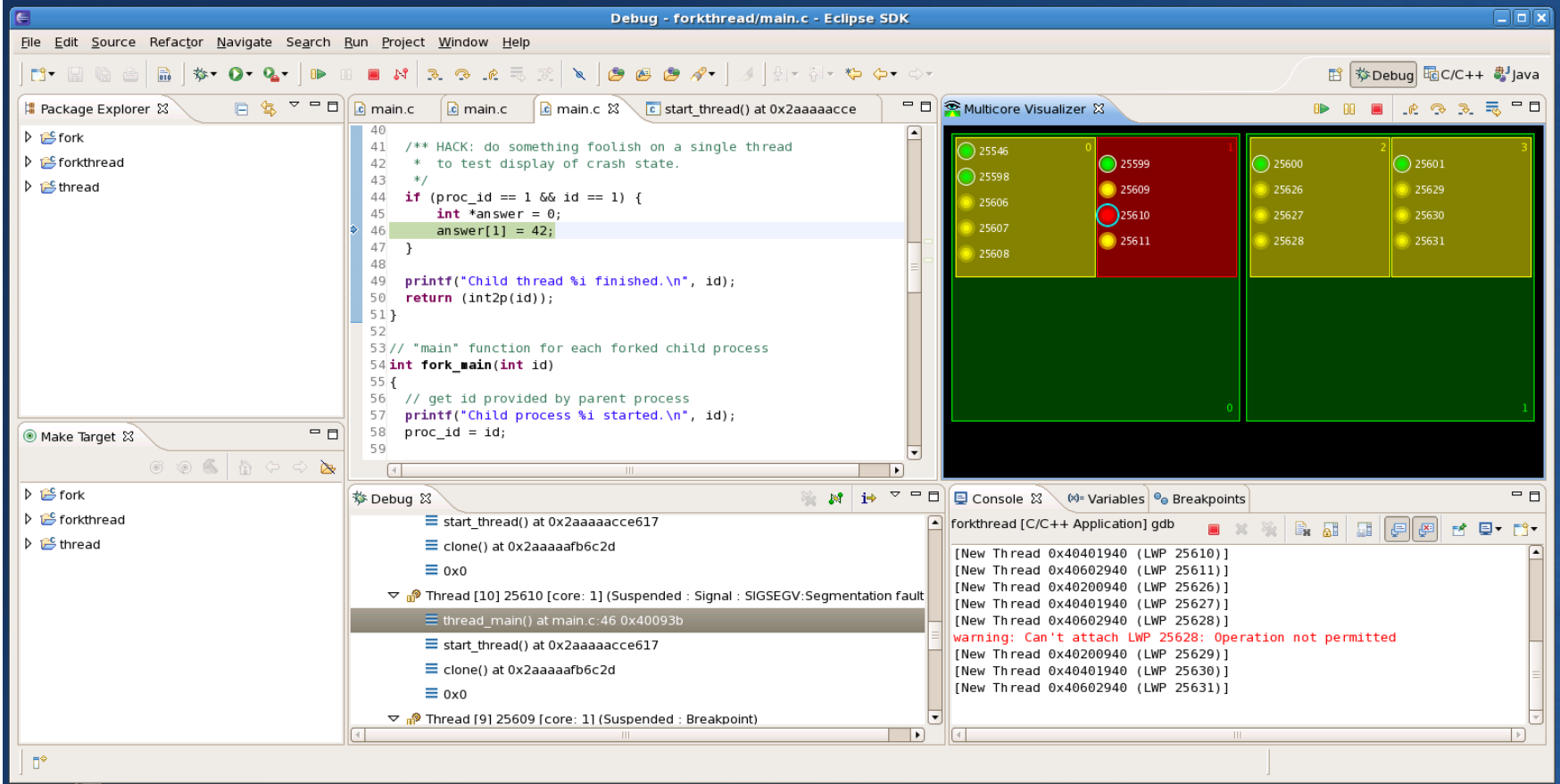
# THE MULTICORE VISUALIZER

› Based on “Grid View” visualization in the Tiler IDE:



# MULTICORE VISUALIZER

## > Demo



The screenshot shows the Eclipse IDE interface with the Multicore Visualizer plugin. The main editor displays the source code for `main.c`, which includes a `fork` function and a `start_thread` function. The visualizer shows a grid of thread states, with each thread represented by a colored circle and its ID. The console output shows the following:

```
forkthread [C/C++ Application] gdb
[New Thread 0x40401940 (LWP 25610)]
[New Thread 0x40602940 (LWP 25611)]
[New Thread 0x40200940 (LWP 25626)]
[New Thread 0x40401940 (LWP 25627)]
[New Thread 0x40602940 (LWP 25628)]
warning: Can't attach LWP 25628: Operation not permitted
[New Thread 0x40200940 (LWP 25629)]
[New Thread 0x40401940 (LWP 25630)]
[New Thread 0x40602940 (LWP 25631)]
```

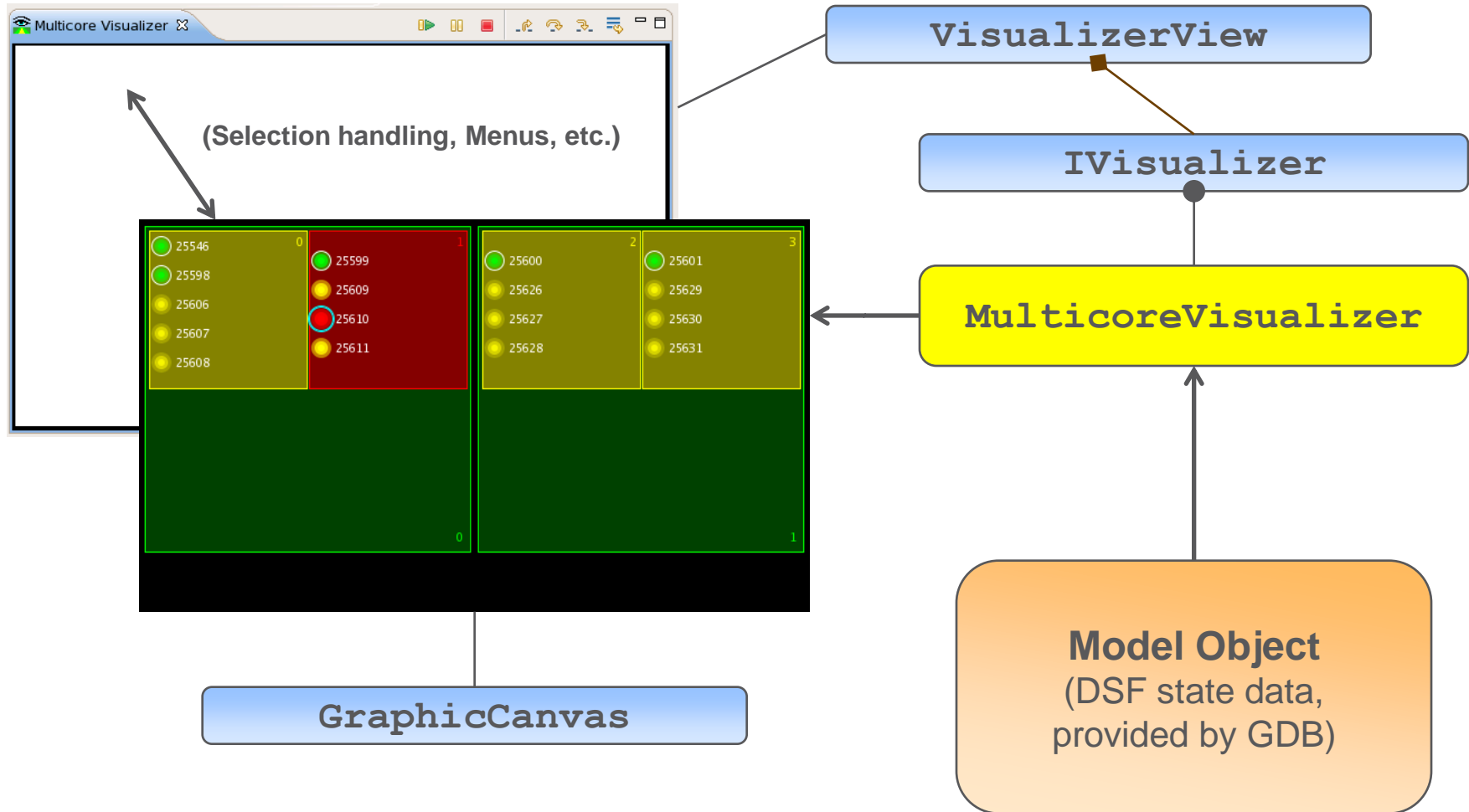
# MULTICORE VISUALIZER

---

## › Demo:

- New Visualizer view in workbench
- Displays cpus, cores, processes & threads
- Sample program to debug: multi-process, multi-threaded
- View updates automatically as program layout changes
- Shows execution state of cpus, cores, processes, threads
- Click/drag selection, updating of Debug View
- Debug View state reflected in Visualizer
- Breakpoint handling (resume, step, etc.)
- Commands accessible from toolbars, context menu, and shortcuts
- Variables view (as usual) reflects current selection
- Displays crashed processes/threads in red
- Can click on problem thread(s) to select and view source
- Especially handy where there are multiple failures!

# VISUALIZER FRAMEWORK



# ON BEYOND DEBUGGING

---

- › There's a framework because one view isn't sufficient
- › Multicore Visualizer is currently aimed at debugging on homogenous multicore platforms; there are others
- › Can extend multicore visualizer to suit your platform
  
- › Also potential visualization uses beyond debugging
  - Visualizations of selected data
  - Use of “overlays” to select different kinds/views of data
  - Static code analysis displays, etc.
- › Framework includes examples you can build upon

# MULTIPLE VISUALIZERS

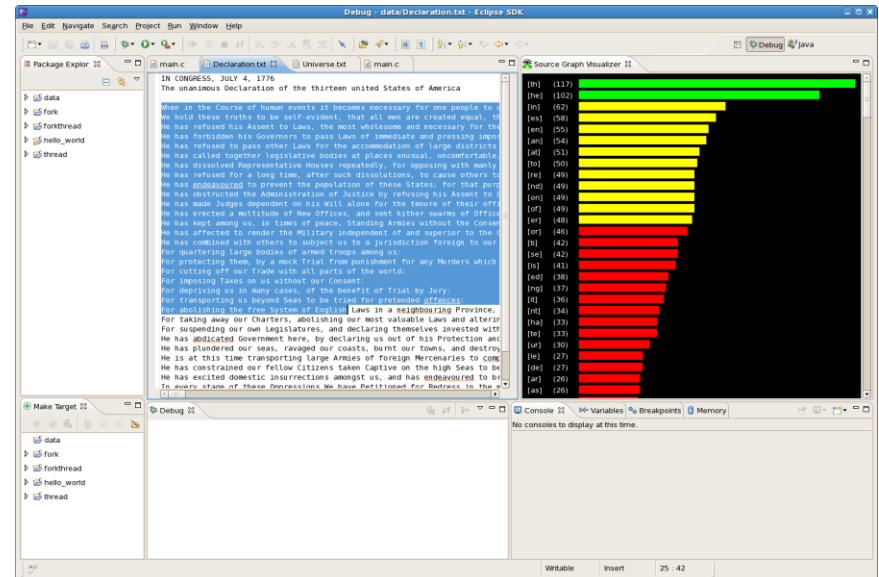
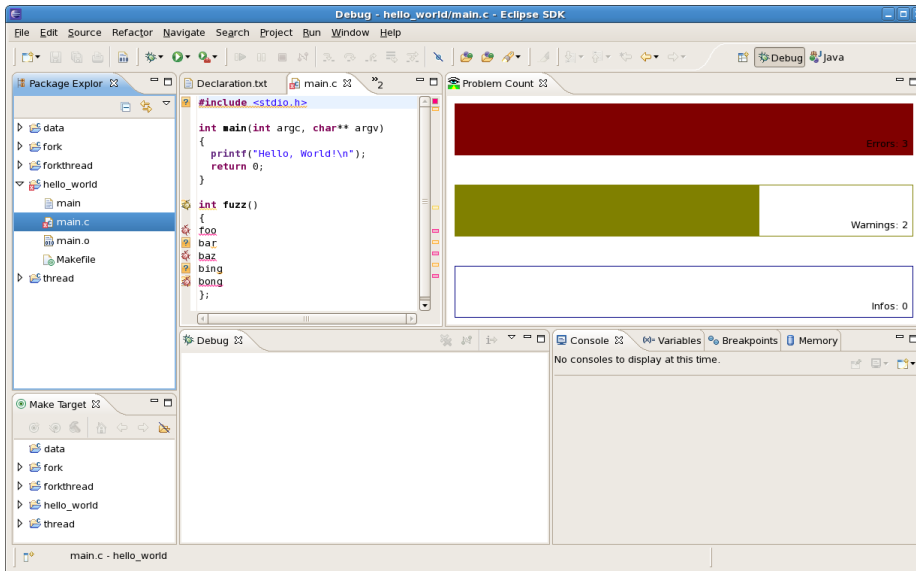
---

- › Displayed visualizer is based on current selection.
- › For multicore visualizer, the selection is DSF-GDB data
- › Can also base visualizer on other information:
  - Selected projects (example: display of warnings/errors)
  - Selected text (program text, etc.)
- › Anything that's selectable can potentially have a visualization associated with it.
  
- › Visualizers report a weight indicating what they can handle
- › The visualizer view selects the right visualizer for the current selection, based on visualizers' reported weights

# MULTIPLE VISUALIZERS

## › Demo:

- problem count visualizer
- source text analysis graph



# SEEING IS UNDERSTANDING

---

- › Visualization is necessary as a “big picture” approach to large applications on multicore hardware
- › You can’t debug what you can’t see
- › What you *can* see, you can understand.
- › What you understand, you can reason and feel sure about



# WE NEED NEW TOOLS

---

- › **The Multicore Visualizer is not an end, but a beginning.**
- › Visualizer exemplifies new kinds of tools and approaches needed for multicore and the “big application” era.
- › These new tools are going to come from YOU the Eclipse developer community.
- › The Visualizer framework provides a platform for development of more (and better!) visualizations.
  
- › Let’s make sure our favorite platform, Eclipse, is ready for the tasks ahead!

# IT TAKES MORE THAN ONE TOOL

---



- › Visualizer is just one of the projects currently being worked on by the CDT Multicore Debug Workgroup

# MULTICORE DEBUG WORKGROUP

---

- › Joint effort to bring multicore debugging to the CDT
  - Visualizer, Pin&Clone, Multiprocess debug, etc
- › Support for those that want to add new features
- › Monthly conference calls (open to all interested and free 😊)
  - <http://wiki.eclipse.org/CDT/MultiCoreDebugWorkingGroup>



# WORKGROUP PLANS

---

- › Process/Thread/Core sets, as supported by GDB
- › Global breakpoints
- › OS Awareness
- › Dynamic Printf
  
- › Fully-integrated GDB console
  - › complete GDB console that can be used jointly with Eclipse
- › Scalability and performance
  - › Ability for GDB to handle 100s or 1000s of threads/processes
- › and more...

# PTC SETS

Process Thread Core (PTC) sets control groups of debug elements:

- Step threads numbered between 34 and 59

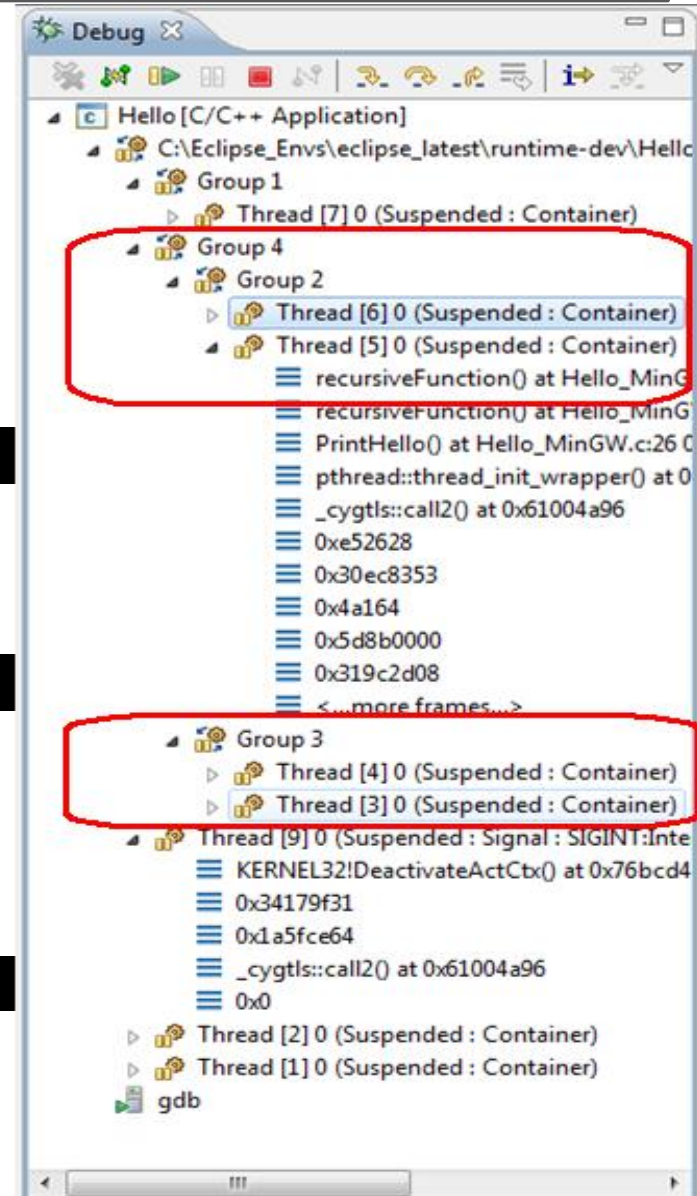
```
(gdb) step .34-59
```

- Step all threads running on core 2

```
(gdb) step @2
```

- Stop everything running on cores 5 to 7, preventing new threads from being started

```
(gdb) interrupt *.future@5-7
```



# GLOBAL BREAKPOINTS

---

Applies to every process

Auto attach when hit

Un-started or short lived process



[ KERNEL MODULE REQUIRED ]

# OS AWARENESS

Sometimes examining OS Resources can help find bug

Message Queues

All Processes

Loaded Kernel Modules

Semaphores





Sockets

All Threads

Process Groups

Shared Memory Segments

File Descriptors

OS resources  Kernel modules   

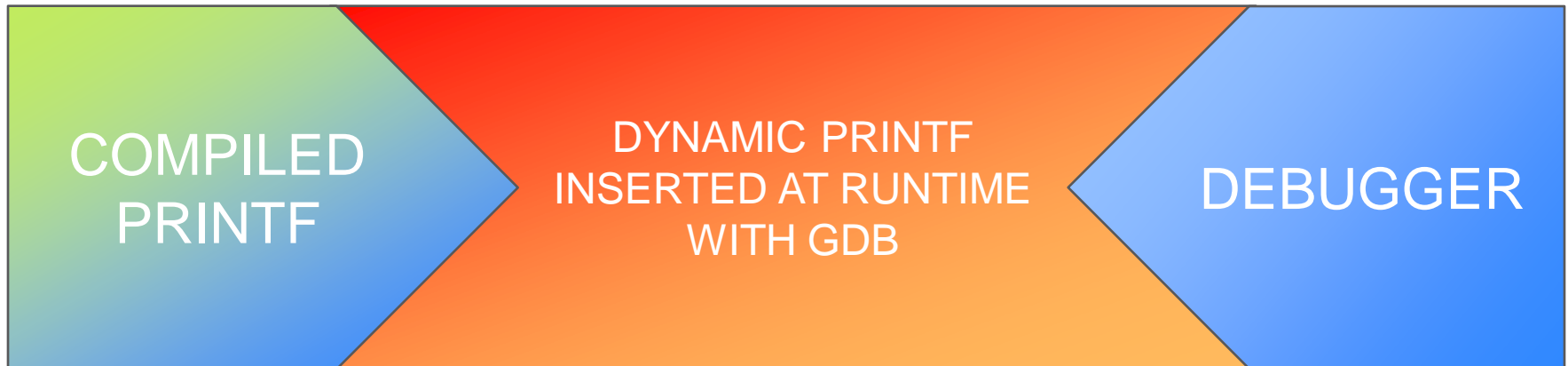
Fetches at 11:37:46

Name	Size	Num uses	Dependencies	Status	Address
aes_generic	26863	1	aes_i586,	Live	f816f000
aes_i586	7268	2	-	Live	f80c8000
agpgart	31724	2	nvidia,intel_agp,	Live	f80cb000
arc4	1153	2	-	Live	f84b7000
binfmt_misc	6587	1	-	Live	f80bf000
bitblit	4707	1	fbcon,	Live	f81a9000
cfg80211	126528	3	iwlgagn,iwlcore,mac80211,	Live	f830b000
cifs	248735	4	-	Live	f8393000
dm_crypt	11331	1	-	Live	f803b000
e1000e	119856	0	-	Live	f8127000
fbcon	35102	71	-	Live	f81f4000
font	7557	1	fbcon,	Live	f81d6000
hid	67032	1	usbhid,	Live	f80fa000



# DYNAMIC-PRINTF

Sometimes tracing is necessary





## SOME REFERENCES

---




- › Multicore Debug workgroup,  
<http://wiki.eclipse.org/CDT/MultiCoreDebugWorkingGroup>
- › CDT project, <http://www.eclipse.org/cdt>
- › CDT Wiki, <http://wiki.eclipse.org/CDT>
- › GDB, <http://sourceware.org/gdb/>
- › Multicore Visualizer, <http://bugs.eclipse.org/335027>

Contact:

[cdt-dev@eclipse.org](mailto:cdt-dev@eclipse.org)

## Q&A

---

- › Thanks for your time.
- › Reminder: you can provide feedback:
  - › 1) go to [www.eclipsecon.org](http://www.eclipsecon.org)
  - › 2) on Visualizer session, click “EVALUATE”
  - › 3) Vote (    ) and add comments!
- › Enjoy the rest of EclipseCon!

**Seeing is** 

**Understanding:**  
**Debugging with  
the Multicore  
Visualizer**

*William Swanson  
[Tilera Corporation],  
Marc Khouzam  
[Ericsson]*

**EVALUATE**

---

Multicore Visualizer Demo Slides, Version 1.0, 3/22/2012