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Parallel Computing Strategies and Implications

Dori Exterman
CTO IncrediBuild.

In this session we will discuss…

- Multi-threaded vs. Multi-Process
- Choosing between Multi-Core or Multi-Threaded development
- Considerations in making your choices
- Scalability
- Summary and Q&A

Moore's Law Going Multicore

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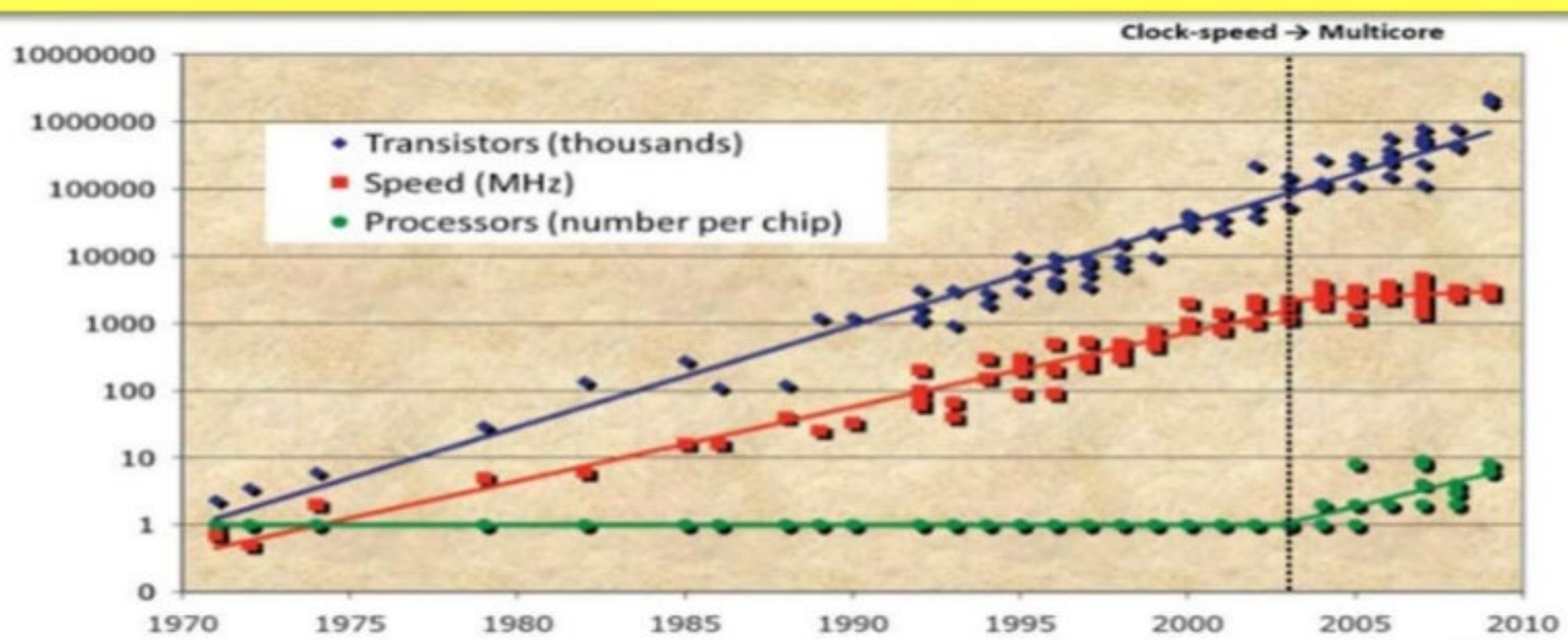
Increase in clock speed, allowing software to automatically run faster. No longer obliged to Moore's law

Instead of doing everything in a linear fashion, programmers need to ensure applications are designed for parallel tasking.



Why is it important to choose well?

- Time to market
- Future product directions
- Product's maintainability
- Product's complexity

Multi-threaded Development: Pros

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- Easy and fast to communicate and share data between threads (espercially read-only).
- Easy to communicate with parent process.
- Beneficial for large datasets that can't be divided to sub sets.
- Supported by many libraries.

Multi-threaded Development: Cons

- One thread crashes → the entire process crashes
- Multi-threaded apps are hard to debug
- Writing to shared data requires a set of (difficult to maintain) locks
- Too many threads → too much time in context-switching.
- Not scalable to other machines / public cloud

Multi-process Development: Pros

- Includes multi-threaded by definition.
- Process crash won't harm other processes.
- Much easier to debug
- Encapsulated – easier to manage for large teams
- Scalable – distributed computing \ public cloud
- More memory can be consumed

Multi-process Development: Cons

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- Custom development required in order to communicate between processes
- Requires special mechanism to share memory data between processes
- Limited “process-safe” libraries

Multi-threaded vs. Multi-core: List of Considerations

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- Parellel parts need to sync data?
- Data sets size
- Ease of development
- Scaling - Compute time and throughput

Synchronization/State Maintenance

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- Easier in multi-threaded
- Easier to debug in multi-threaded
- In multi-process, will require custom development
- Many mechanisms exists both for multi-process and multi-threaded

Ease of Development – Multi-Threaded vs. Multi-Process

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- Pre-made libraries for MT (multi-threaded)
- **MP** - Easier debug/maintenance/code understanding / less bugs will be introduced with new commits
- **MP** - Can be developed and maintained by less experienced developers
- **MP** - Requires developer to maintain encapsulation
- Bugs are less complicated to solve when **MT** is not involved

Throughput & scalability - 1/2

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- How many tasks do I have to execute in parallel – dozens /millions
- How many tasks will my product need to support in the future?
- How much time will each task take? Milliseconds or minutes?
- How much memory will each task require?
- How large is the data that each task requires?

Throughput & scalability - 2/2

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- How complex is each task's code?
- Is my system real-time?
- Would the product benefit from scalability?
- Business wise - scalability as a service?
- Offloading

Other Scalability Questions

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- Do my tasks require special hardware?
- Will my tasks perform better with specific hardware?
- Connection to a database

Common scenarios for using multi-threaded

- Simple scenarios
- Real-time performance
- Long initialization time with short computation time
- Communication, synchs and states
- Only a few highly intensive tasks

Common scenarios for using multi-process

- Multiple, encapsulated modules
- Tasks may require much memory
- Limited synchronization required
- Large application \ large team
- Scaling \ High-throughput
- Tasks are complex and prawned to errors

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Parallel Computing

The **High-Throughput** Challenge

Let's have a look at a real-life scenario

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Maven vs **Make** build tools

- Popular tools
- Many tasks
- Tasks are atomic
- Minimal communication
- Small dataset
- Scalable

Scenarios – Build system approach: Maven

- **Multi-threaded code was only added recently:**

Scenarios – build system approach: Maven

- **Not Scalable: Users are asking for it, but it is still missing multi-process invocation.**
- **Projects are building many 3rd parties.**

Distributed build with maven?

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Currently, we have a maven project with a few thousand tests that takes two hours to run. We've tried running these in parallel, but since they are functional tests, each test configures the system in a specific way, which leads to race conditions and random test failures. What I'd like to do is spin up N servers on AWS, then have maven divide my tests up and run them on these servers (each

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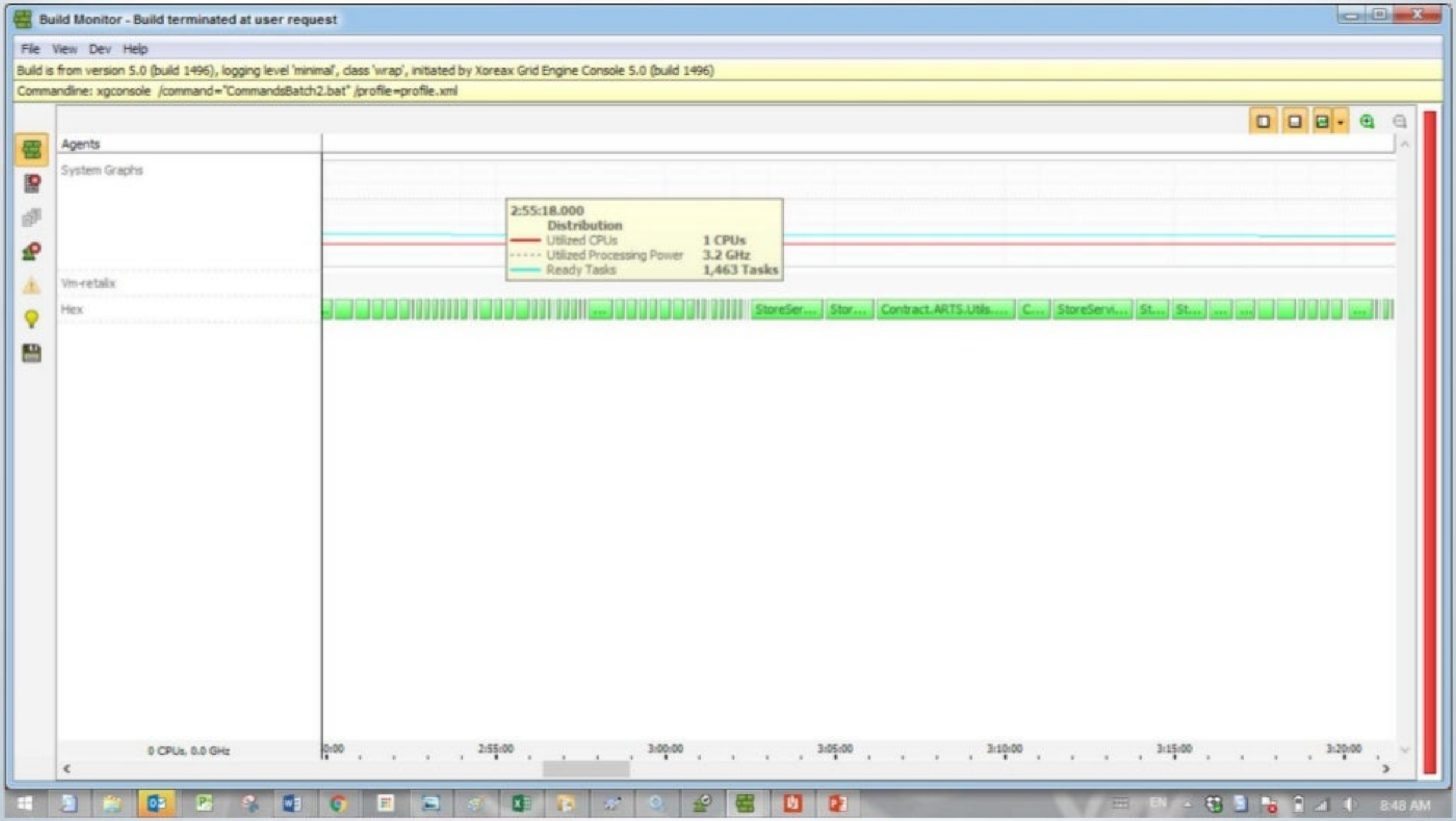
Distcc makes it easy to distribute a C or C++ compile job across a number of machines, and is a godsend for working with large, frequently-built codebases.

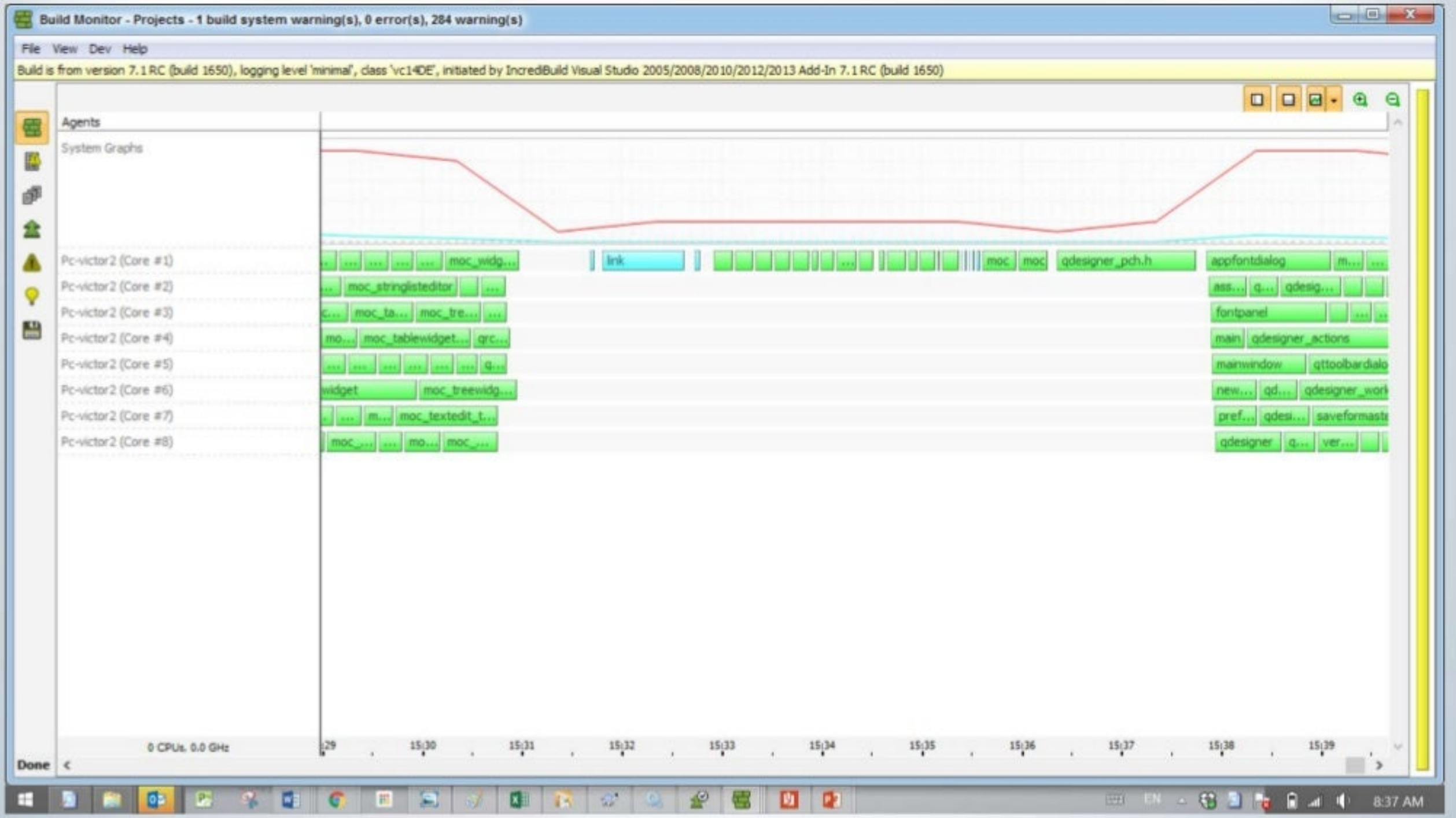
An increasing number of our large projects are built in Java these days, however. Does anyone know of something equivalent or similar for Java? While it would be great if it would go down to the **javac** level, our multi-module projects would benefit from being able to distribute each maven 2

Single Machine, Single Core



Single Machine – Multi-Core

8 cores, 15:45 minutes



Make

- **Multi-process (same as other modern build tools)**
- **Better memory usage**
- **Caching add-ons (CCache)**
- **Scalable – 3rd party solutions (DistCC, IceCC, IncrediBuild)**

QT on Single Machine – Multi-Core

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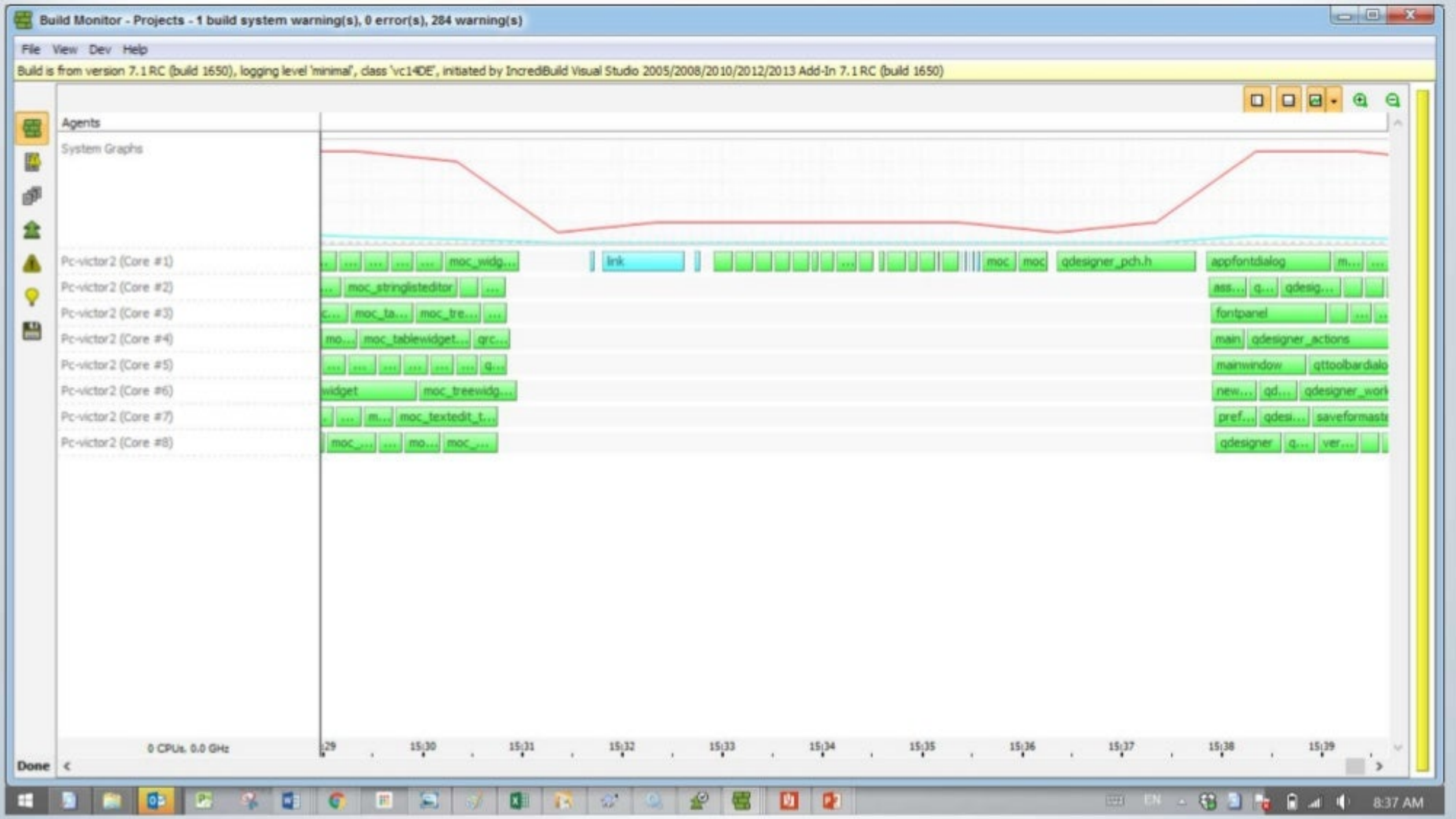
8 cores, 15:45 minutes



QT on Single Machine – Multi-Core (predicted)

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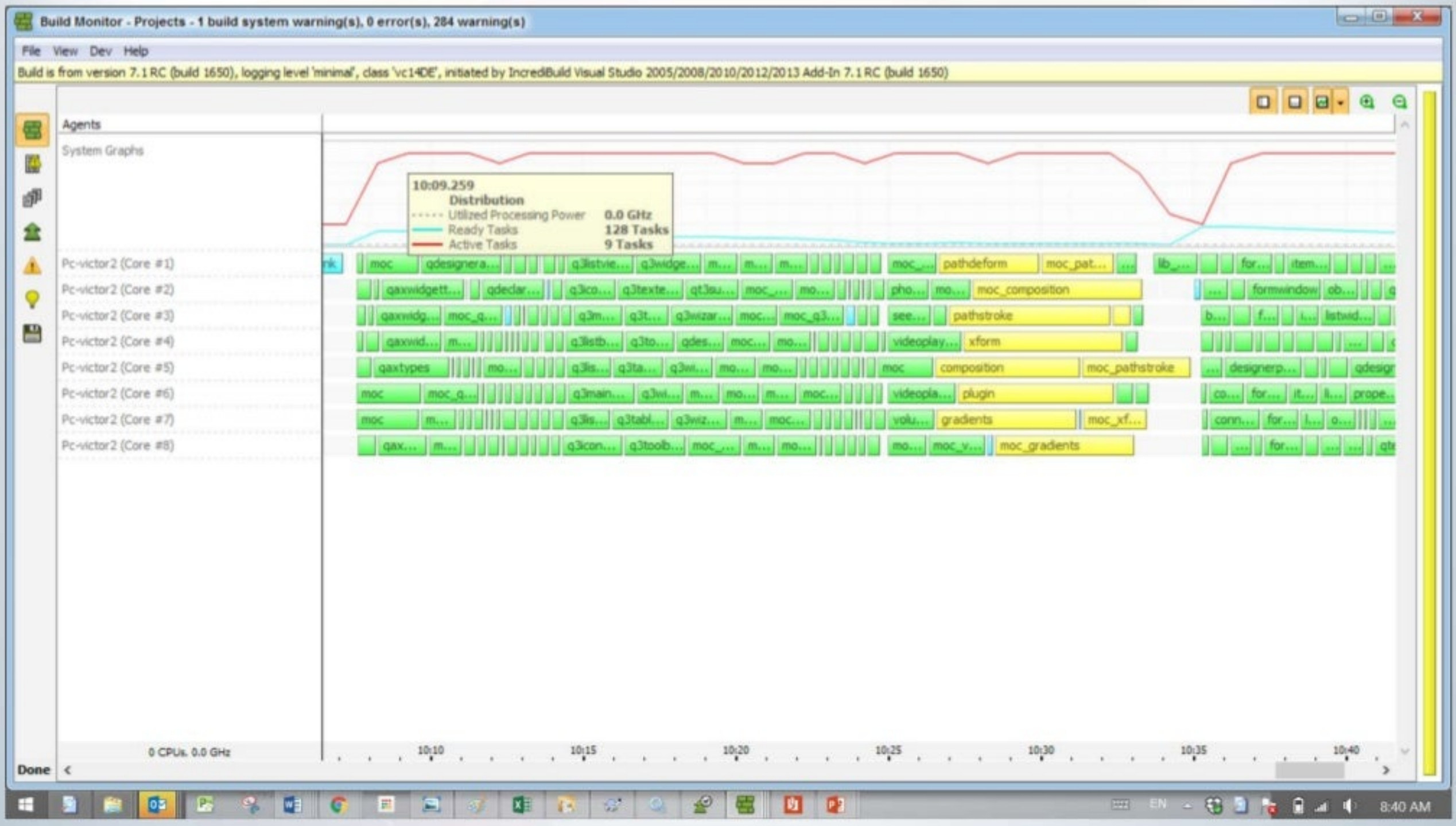
8 cores, 11 minutes



QT on multiple machines, ~200 cores

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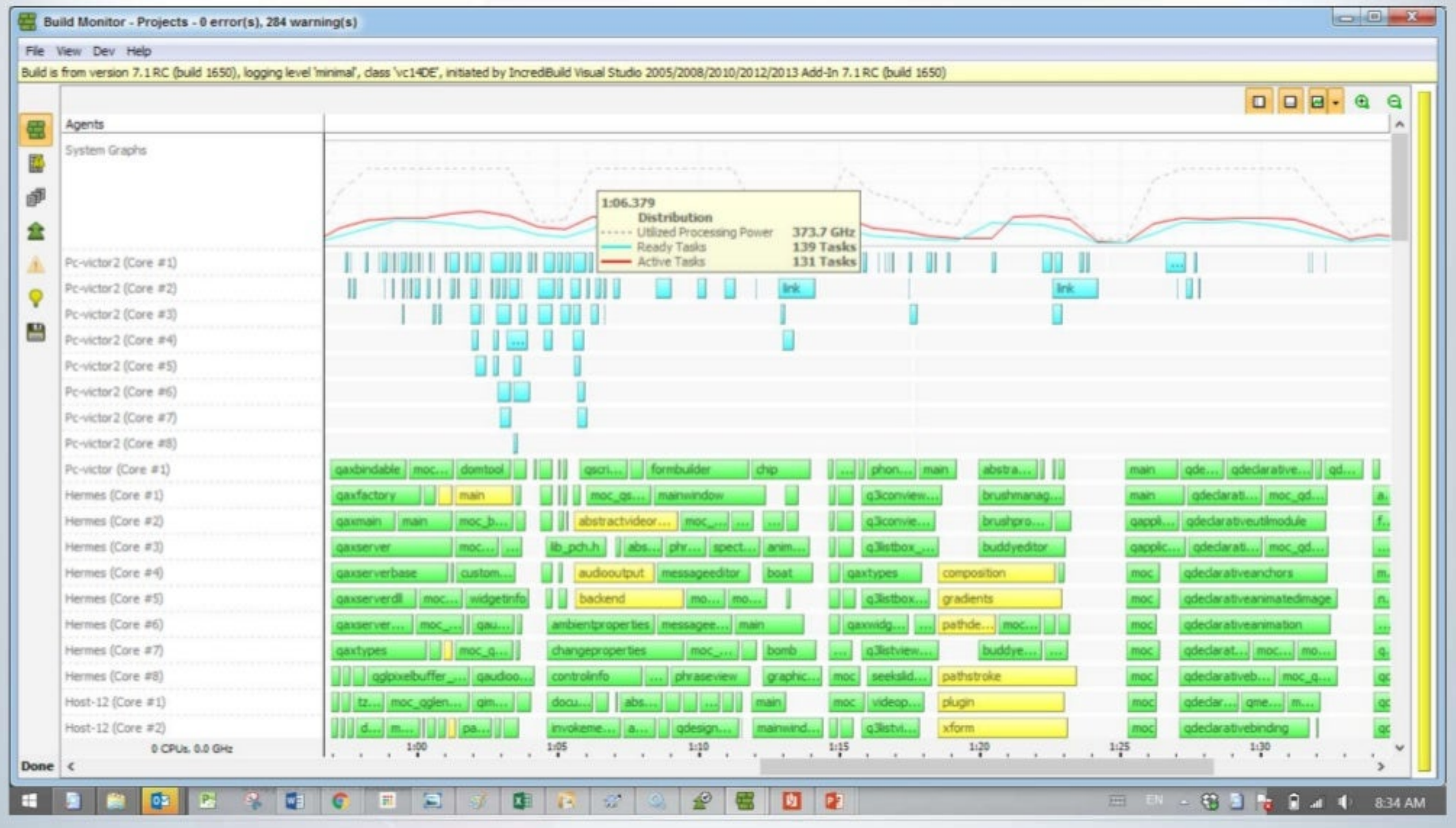
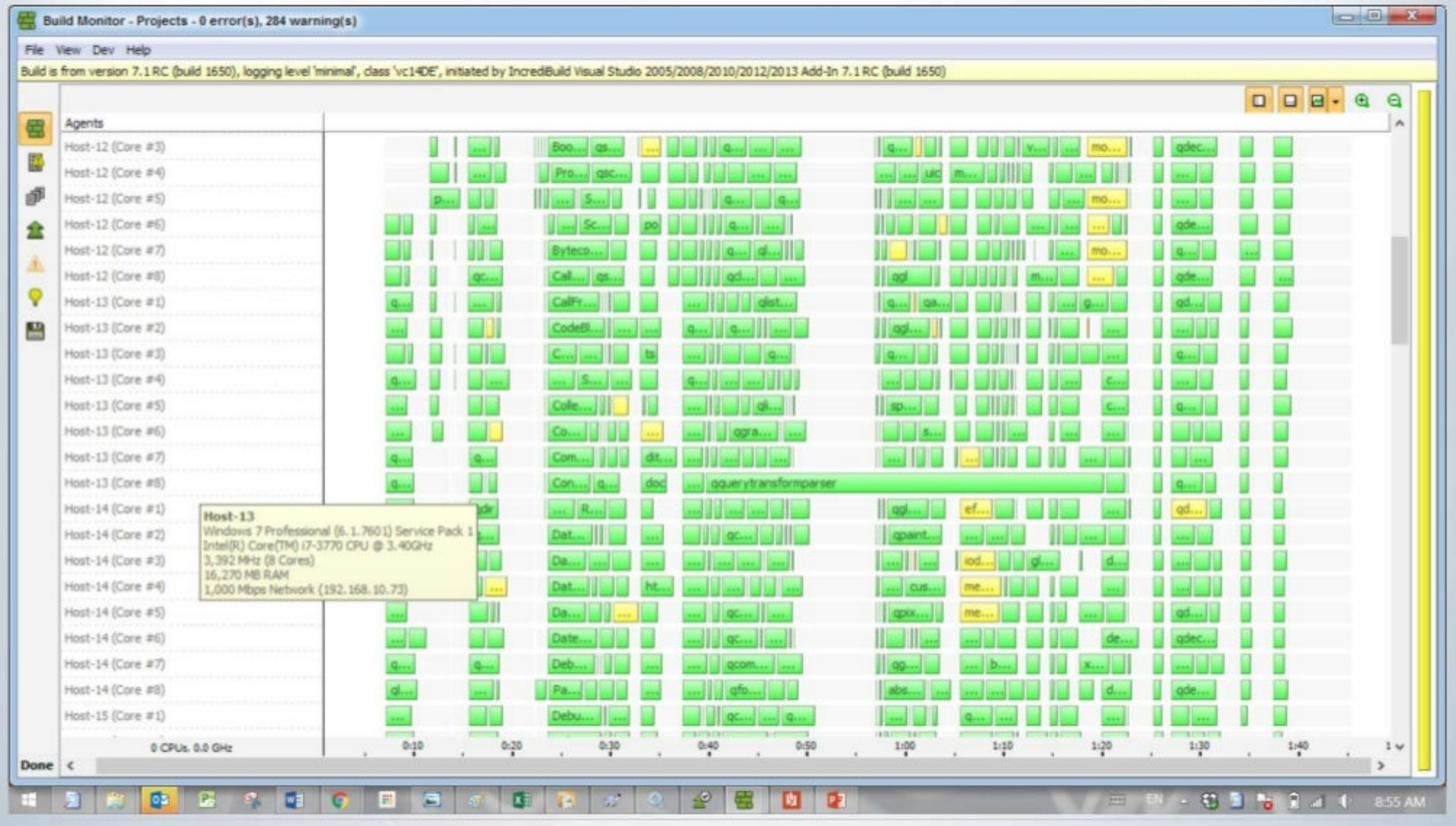
130 cores, 1:40 minutes



QT on multiple machines, multi-core

130 cores, 1:40 minutes



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Real Life Scenarios

Common high-throughput scenarios and decision

Multi-threaded:

Large in-memory read \ write meshes:

- CAD
- AI (connections between elements)
- Weather forecasting
- Genetic algorithms

Needs all the data to be in-memory and accessible for all tasks.

Common high-throughput scenarios and decision

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Multi-threaded:

Real time performance needs:

- Financial transactions
- Defense systems
- Gaming

Latency and initialization time are very important.

Common high-throughput scenarios and decision

Multi-Threaded:

Applications which most of the calculation (business logic) is Database related (stored procedures, triggers, OLAP)

CRM, ERP, SAP

Common high-throughput scenarios and decision

Multi-threaded:

Fast sequential processing:

- CnC
- Manufacturing line
- Dependent calculations

Next calculation depends on the previous one.

Common high-throughput scenarios and decision

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Multi-threaded:

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Common high-throughput scenarios and decision

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Multi-Processing:

Large independent dataset: when we don't need all data in-memory at the same time.

Low dependencies between data entities.

- Simulations (transient analysis) – Ansys, PSCad
- Financial derivatives – Morgan Stanley
- Rendering

Common high-throughput scenarios and decision

Multi-Processing:

When we have Many calculations with small business units.
Solution: batch tasks

- Compilations
- Testing (unit tests, API tests, stress tests)
- Code analysis
- Asset builds
- Math calculations (Banking, Insurance, Diamond industry).

Common high-throughput scenarios and decision

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Multi-Processing:

GPU – applications that scale to use many GPUs

- CUDA, OpenCL
- Rendering
- Password cracking

Common high-throughput scenarios and decision

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Multi-Processing:

Output and computation streaming:

NVIDIA Shield, Onlive Service, Netflix, Waze

NETFLIX

onLIVE

The business aspect

Multi-Processing:

- Scalability
- Offloading
- Full cloud solution
- SAAS

Summary

Summary - Writing Scalable Apps:

Architectural considerations:

- Can my execution be broken to many independent tasks?
- Can the work be divided over more than a single host?
- Do I have large datasets I need to work with?
- How many relations are in my dataset?
- How much time would it take my customers to execute a large scenario – do I have large scenarios?

Summary - Writing Scalable app:

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Technical considerations:

- Do I have any special communication and synchronization requirements?

- Dev Complexity - What risks can we have in terms of race-conditions, timing issues, sharing violations – does it justify multi-threading programming?

- Would I like to scale processing performance by using the cloud or cluster?

Distributed Computing

Some of the known infrastructures to using multi-core/multi-machine solutions:

- MapReduce (Google – dedicated grid)
- Hadoop (Open source – dedicated grid)
- Univa Grid Engine(Propriety – dedicated grid)
- IncrediBuild (Propriety - ad-hoc \ process virtualization grid)

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Q&A

Dori Exterman, IncrediBuild CTO
dori@incredibuild.com

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