



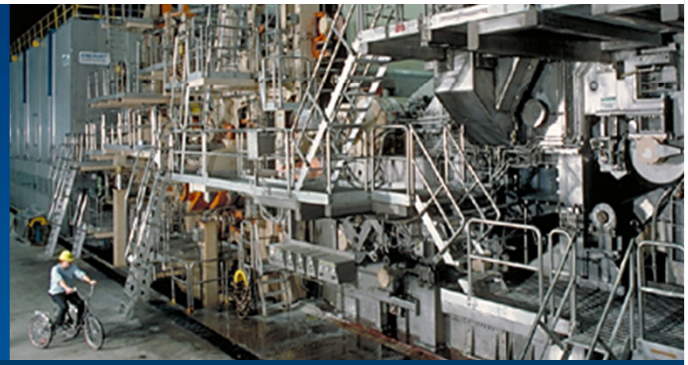


Tracealyzer™

Next-Generation Trace Diagnostics for Embedded Software Systems

Distributed in the UK by Phaedrus Systems Ltd www.phaedsys.com

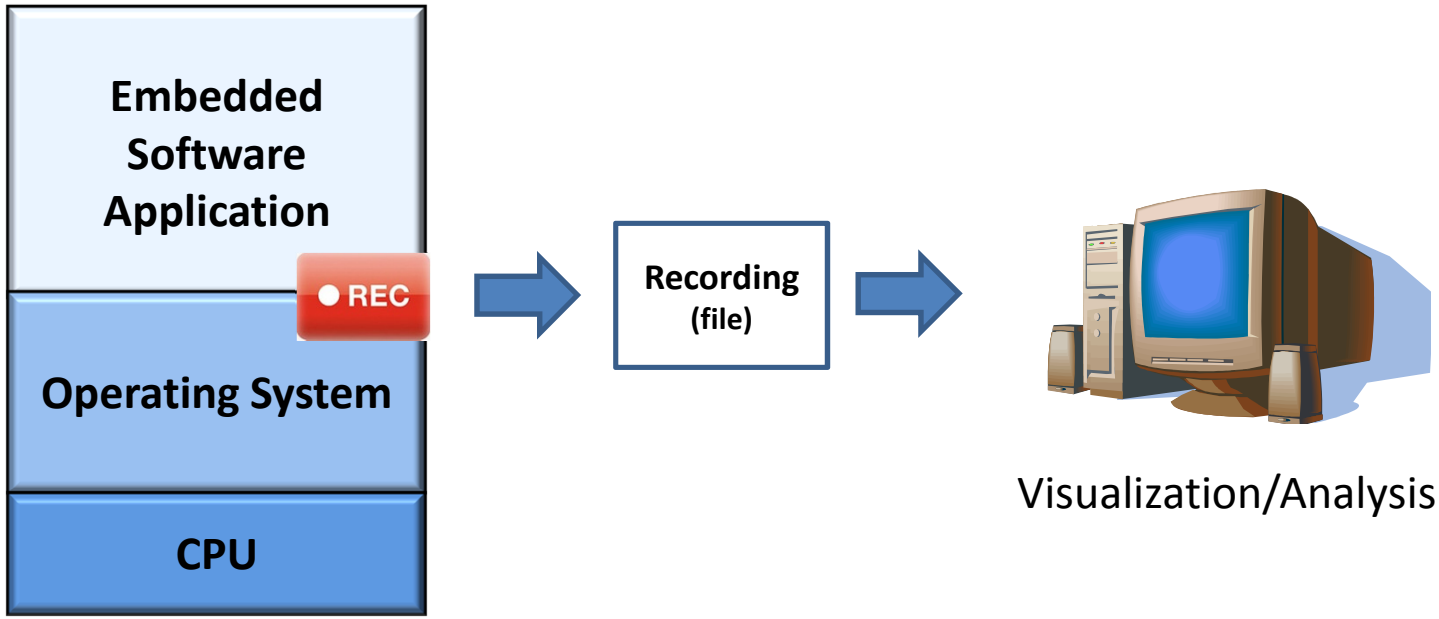


www.percepio.com

percepio
SENSING SOFTWARE

Embedded Software Tracing



Uses of Tracing

Complex errors – where a detailed history is needed
Rare, transient errors – hard to reproduce with a debugger

Uses of Tracing

Timing problems and CPU overload – timeouts!

Uses of Tracing

Resource conflicts on mutexes, queues, semaphores, etc.

Hardware vs. Software Trace

Hardware trace

- Generated by CPU features
- Exact instruction sequence
- Non-intrusive
- Often only control-flow trace
  - General data trace require special chips and boards due to high data rates…
- For lab use only
- Examples:
  - Lauterbach Trace-32
  - iSystem Bluebox
  - ARM ETM

Software trace

- Generated by software
- Higher level – OS events
- Uses target CPU and RAM
- High-level ctrl/data trace
  - Advanced analysis possible
- No extra hardware needed
  - For lab use
  - As crash recorder in field use
- Examples:
  - Wind River System Viewer
  - Percepio Tracealyzer

Overhead of Software Trace?

CPU time

- Typical range: 0.5 - 5 %
  - Event rates: 1 - 10 KHz
  - Storage time: 1 - 10 µs
  - Lower on faster systems
- Compensated by better means for optimization

RAM usage

- Traditional: 8-16 byte/event
- Percepio's: 4 byte/event
  - Even MCUs can accomodate a decent trace buffer!
- Ring-buffer allows for continous use

What about the "probe effect"?

Can be eliminated by keeping the tracing active in release

Diagnostic traces are then always available!

Software Tracing vs. Logging

Tracing

- An OS/platform feature
- High rate
  - Example: context-switches
- Binary format
  - Text converter
  - Specialized graphical viewer

Logging

- Application specific
- Lower rate
  - Example: errors, warnings, other debug information
- Text format

Tracealyzer offers both!

Percepio AB

- Spin-off from applied research in embedded software analysis. Located in Sweden.
- Our Focus:
  - Innovative Trace Visualization
  - Efficient Software Tracing Techniques
  - Support for High-end Hardware Trace Debuggers

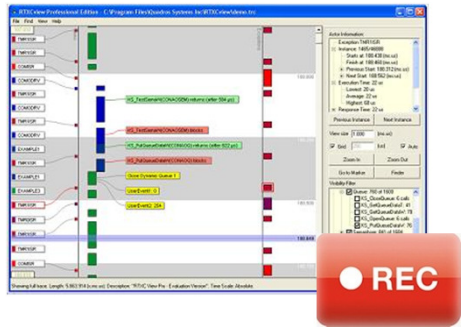
The Tracealyzer™ Tool Family

- v1.x:
  - ABB Robotics/VxWorks (2004) – in every industrial robot from ABB since 2005!
- v2.x:
  - Quadros RTXCview (2011)
  - FreeRTOS+Trace (2012)
  - Rapita Systems RapiTrace (2012)
  - Tracealyzer for On Time RTOS-32 (2012)
  - …

ABB Robotics

"ABB Robotics is using the first generation Tracealyzer in all of the IRC5 robot controllers shipped since 2005. The tool has proven its value many times in all corners of the world."

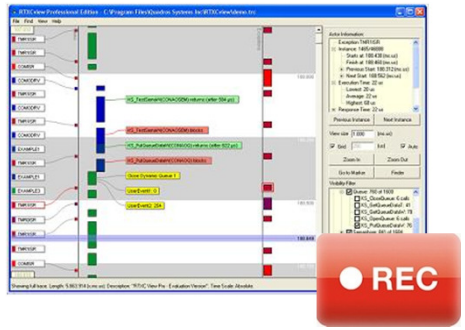
Roger Kulläng, Global System Architect, ABB Robotics.



Telcred

"FreeRTOS+Trace have enabled us to better understand and further improve our embedded software. Using this tool we have been able to identify performance bottlenecks and solve problems, which otherwise would have been very hard to analyze."

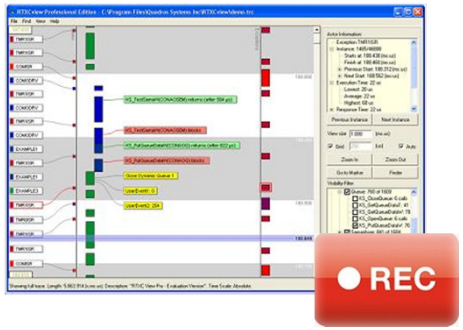
Carlo Pompili, CEO, Telcred AB.



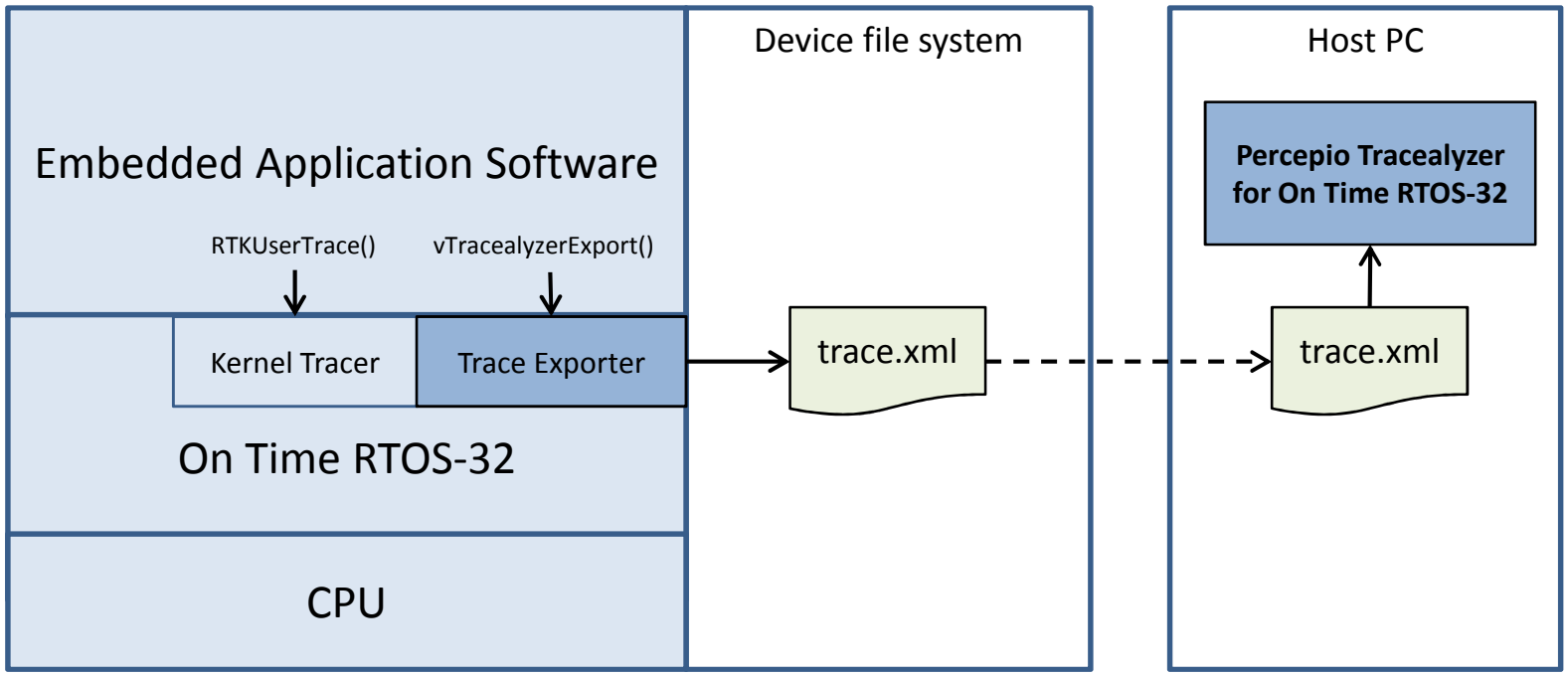
Serious Integrated

"In less than 5 days from running the tool, we improved the performance of our graphic rendering engine by 3x!"

Terry West, CEO, Serious Integrated Inc.



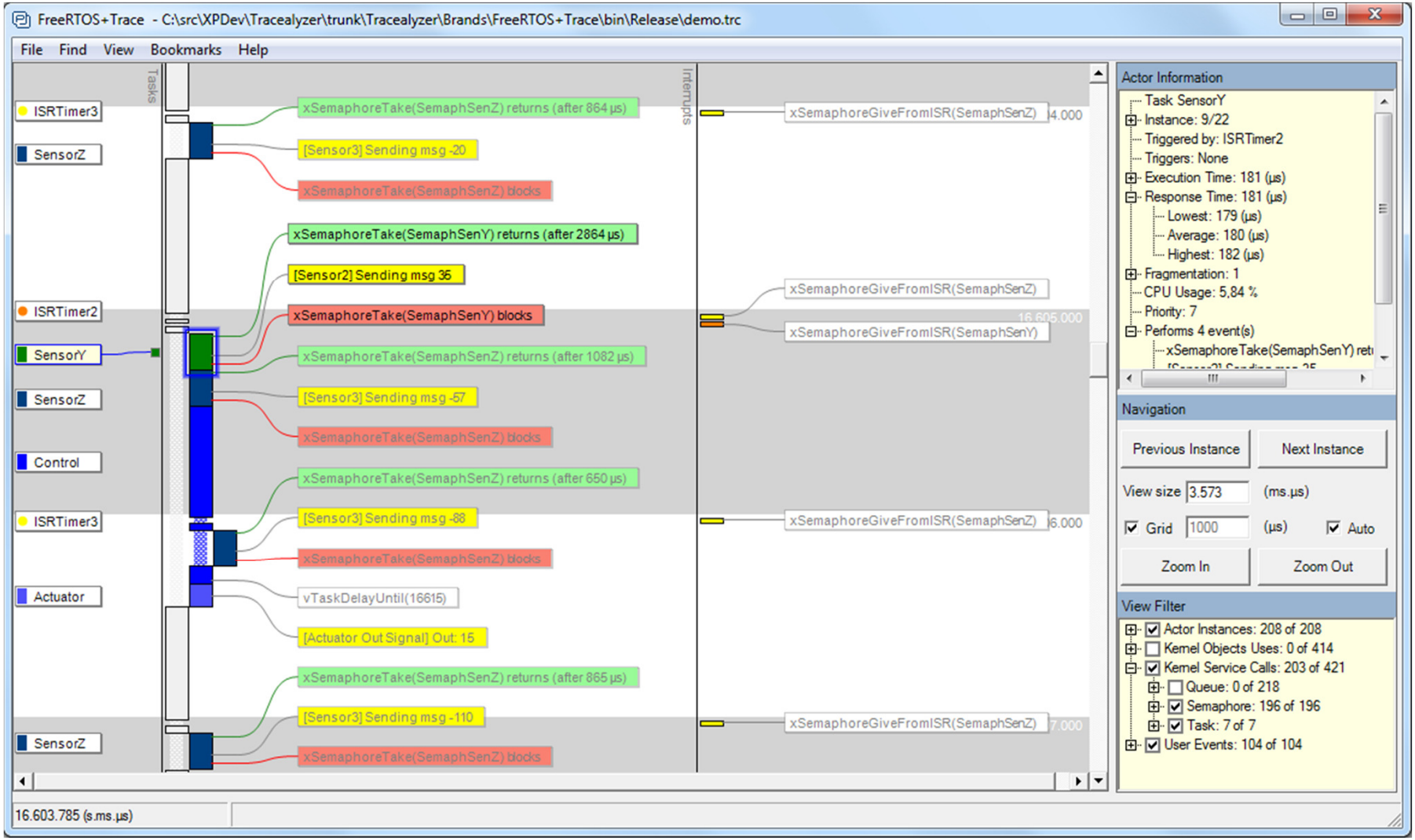
Tracealyzer for On Time RTOS-32



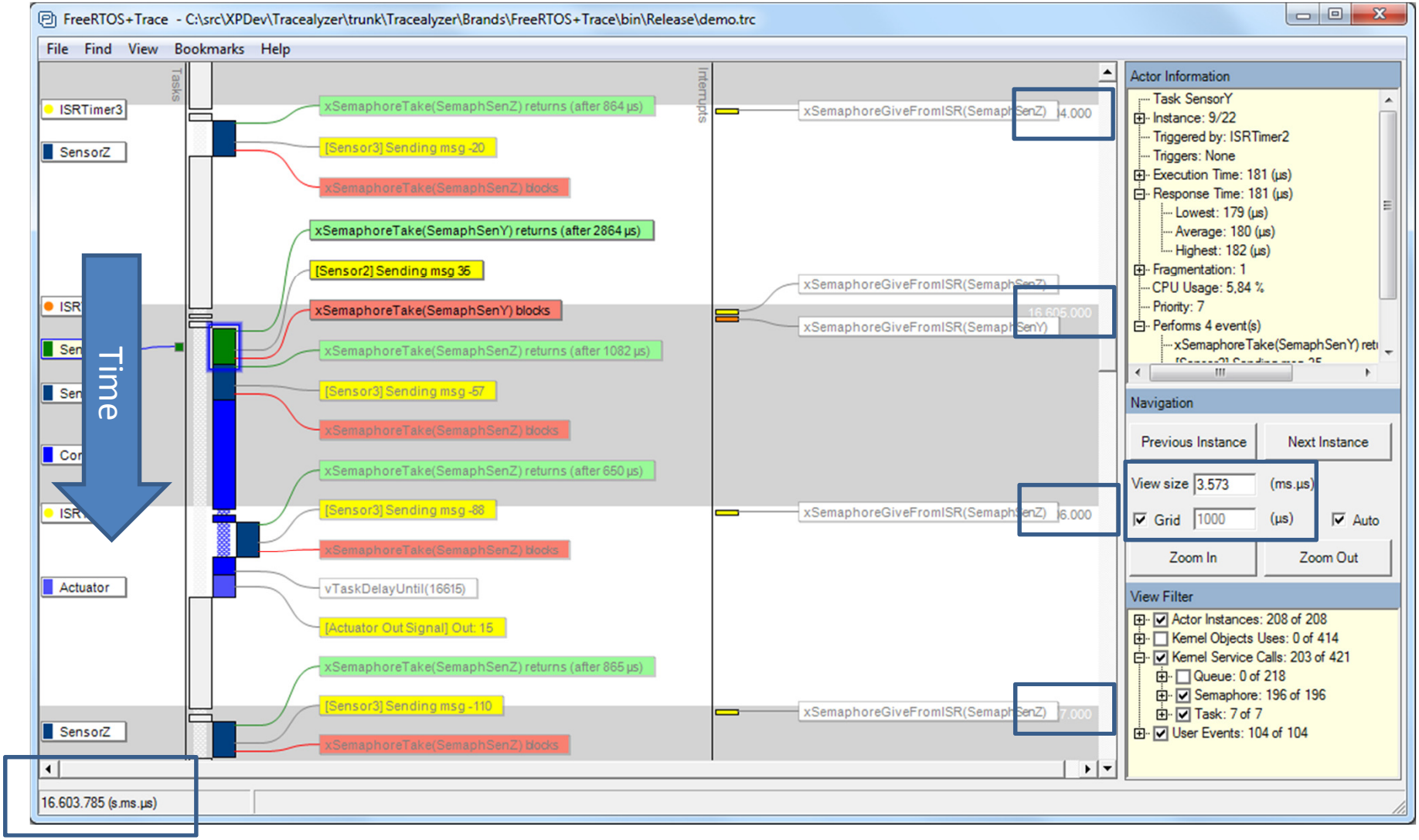
On Time
REAL-TIME AND SYSTEM SOFTWARE

Tracealyzer Visualization

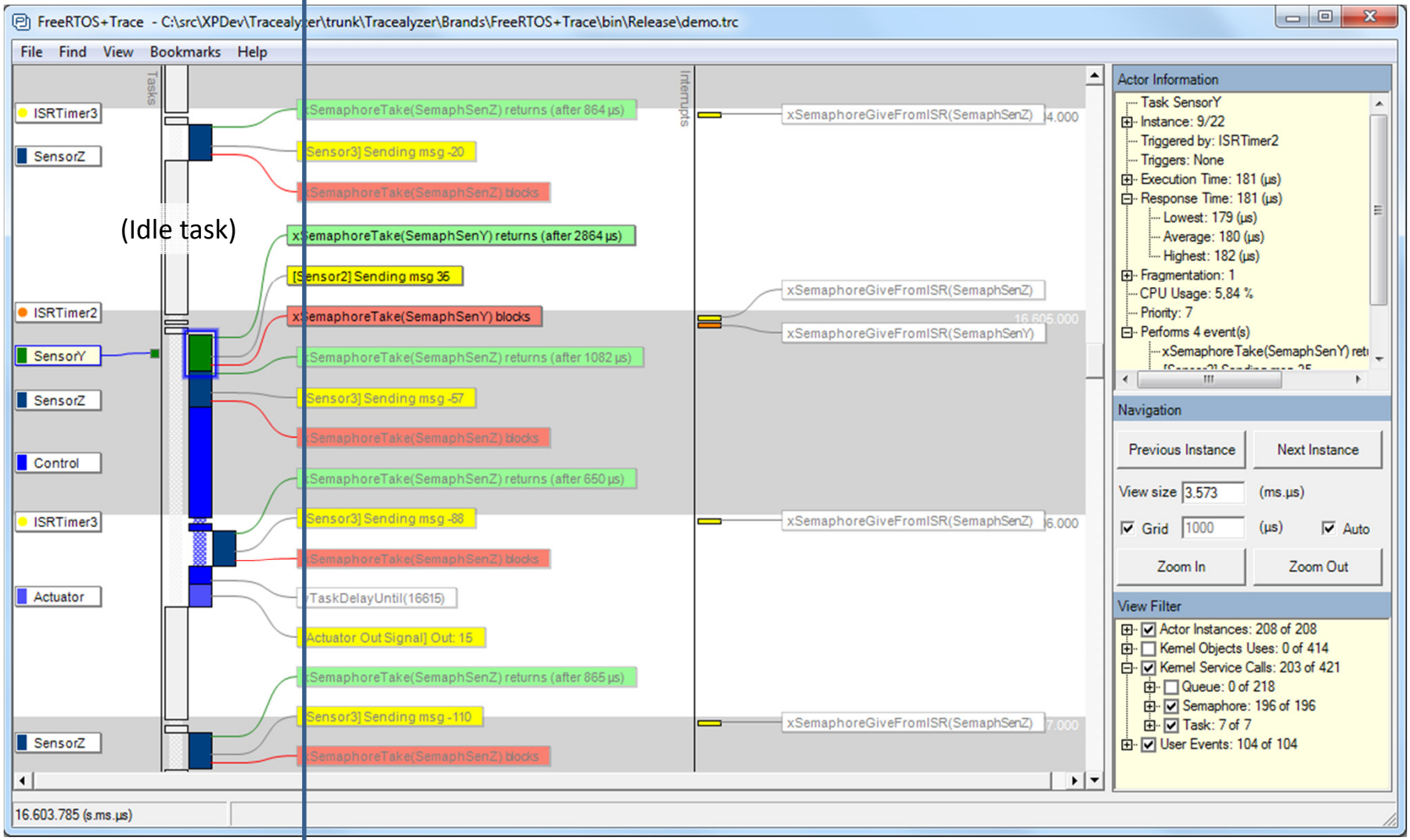
The Main Trace View



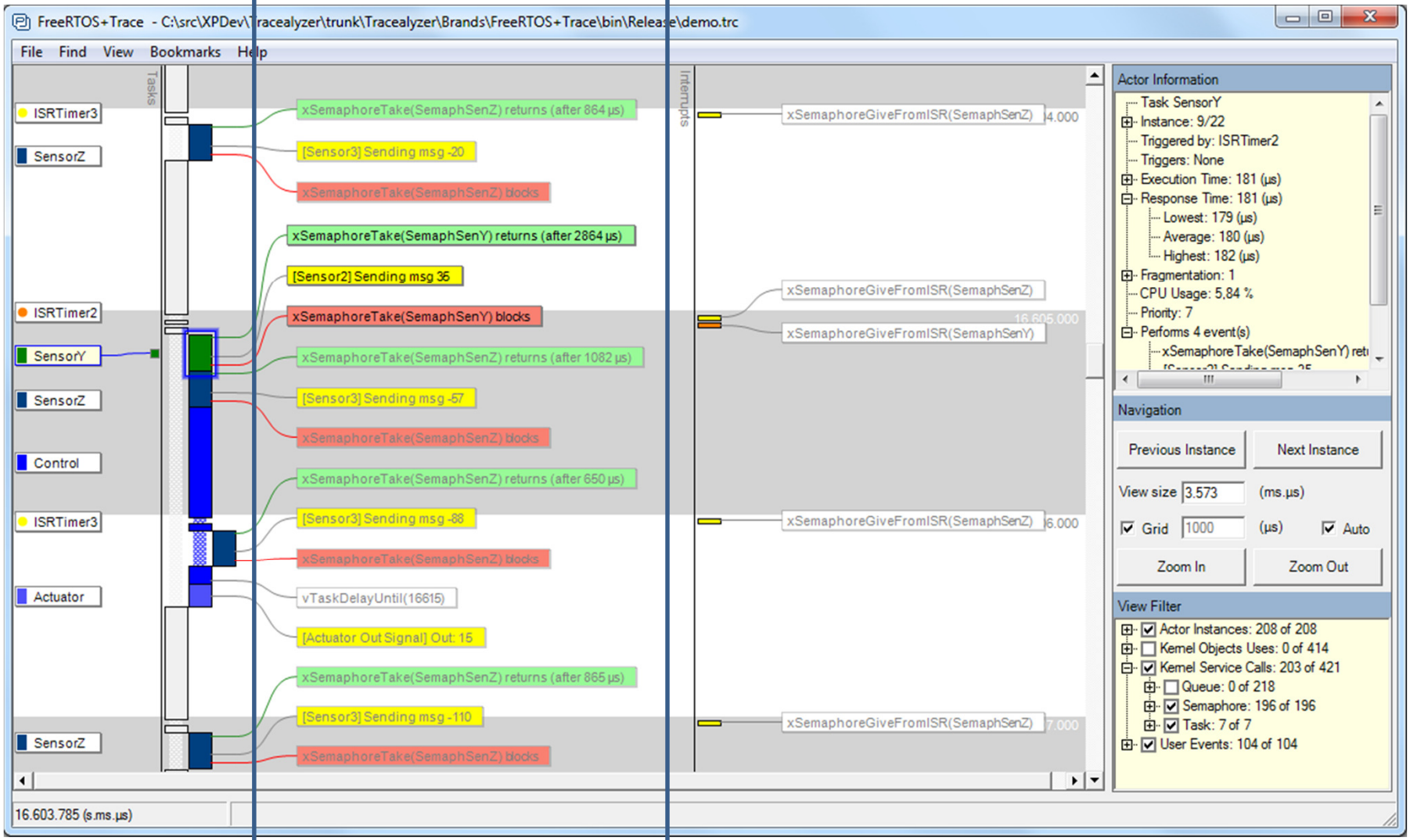
The Main Trace View – Time Scale



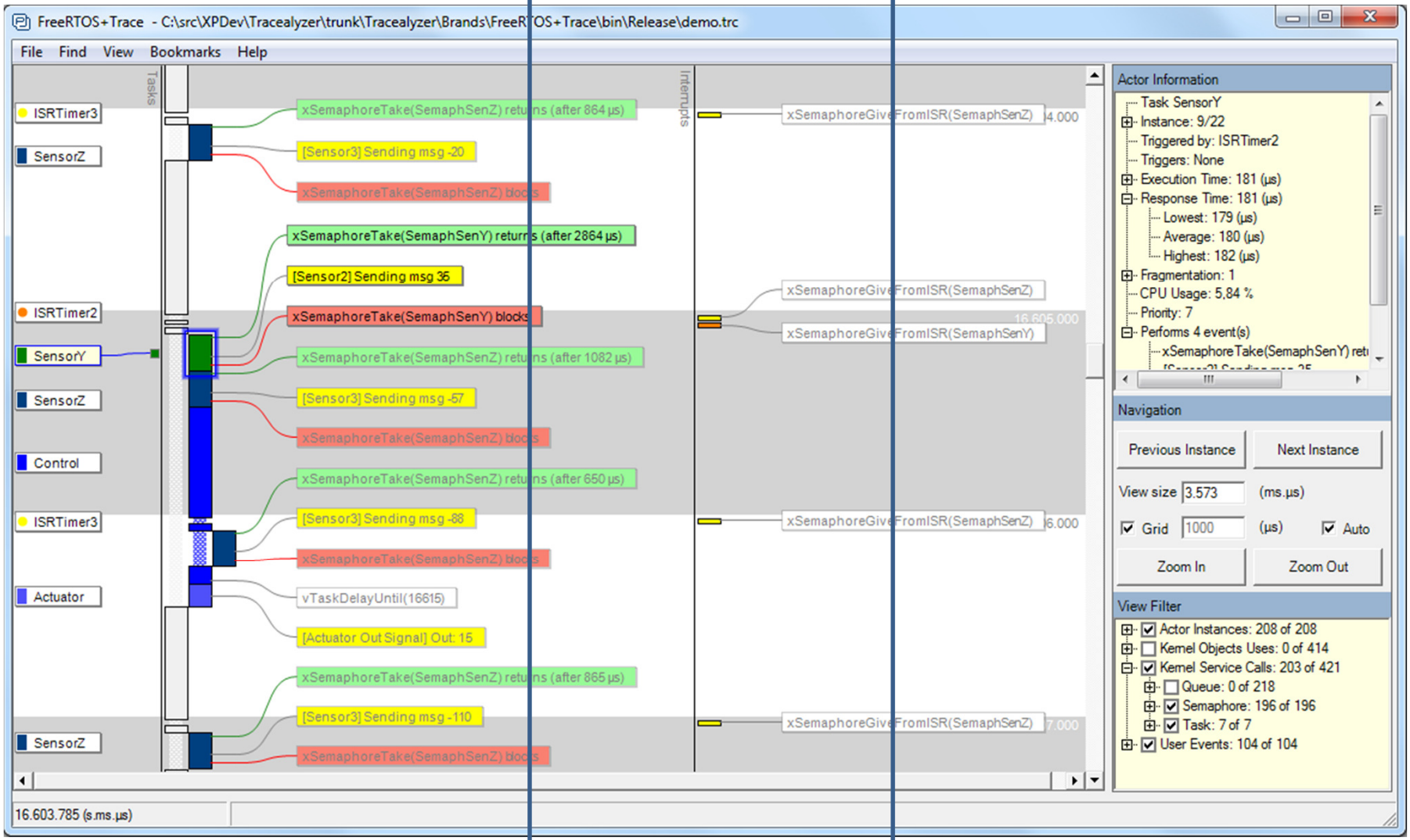
Tasks


FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
(Idle task)
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
Sensor3] Sending msg -20
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenY) returns (after 2864 µs)
[Sensor2] Sending msg 36
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
16.603.785 (s.ms.µs)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Performs 4 event(s)
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
Zoom In
Zoom Out
View Filter
Actor Instances: 208 of 208
Kernel Objects Uses: 0 of 414
Kernel Service Calls: 203 of 421
Queue: 0 of 218
Semaphore: 196 of 196
Task: 7 of 7
User Events: 104 of 104

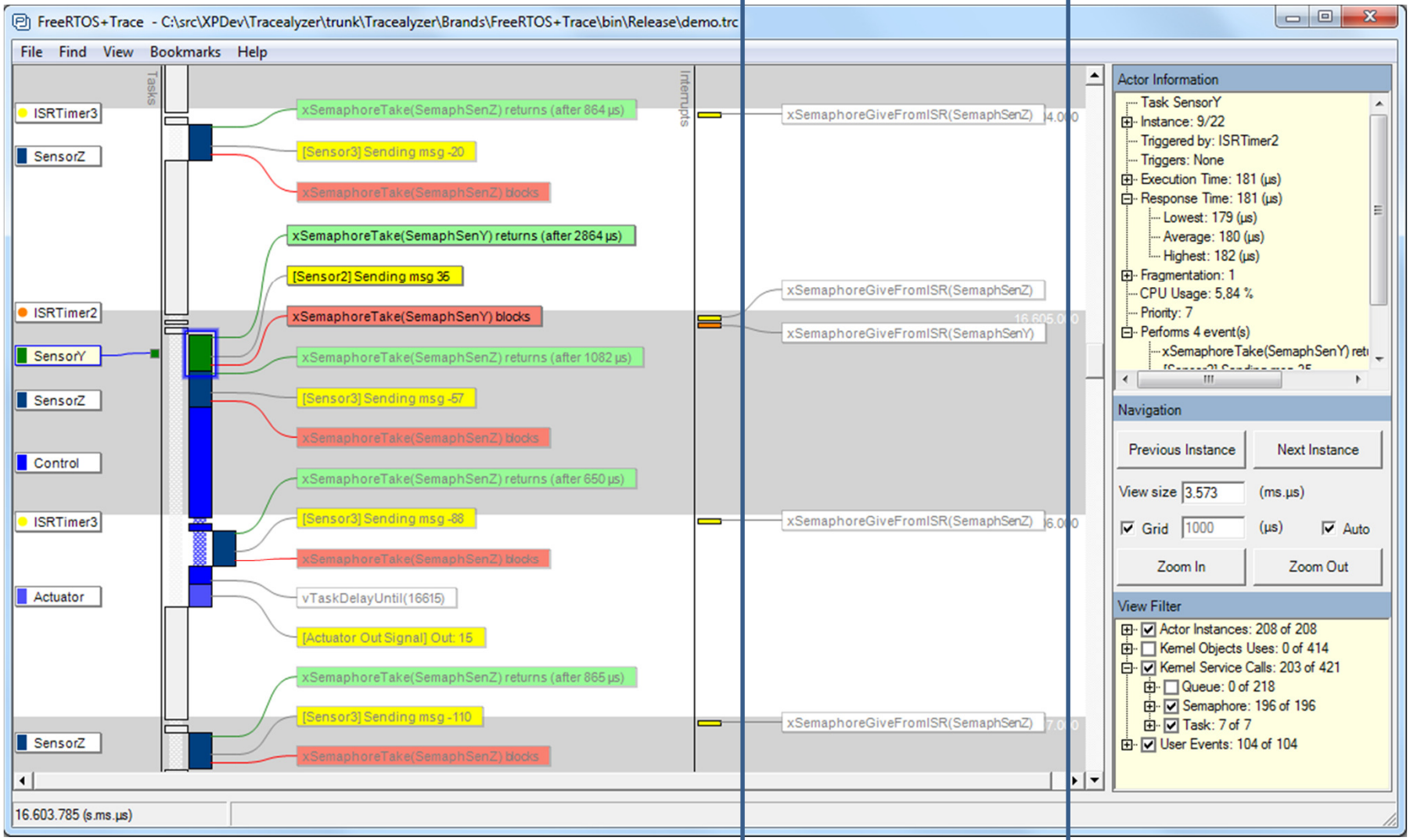
System calls



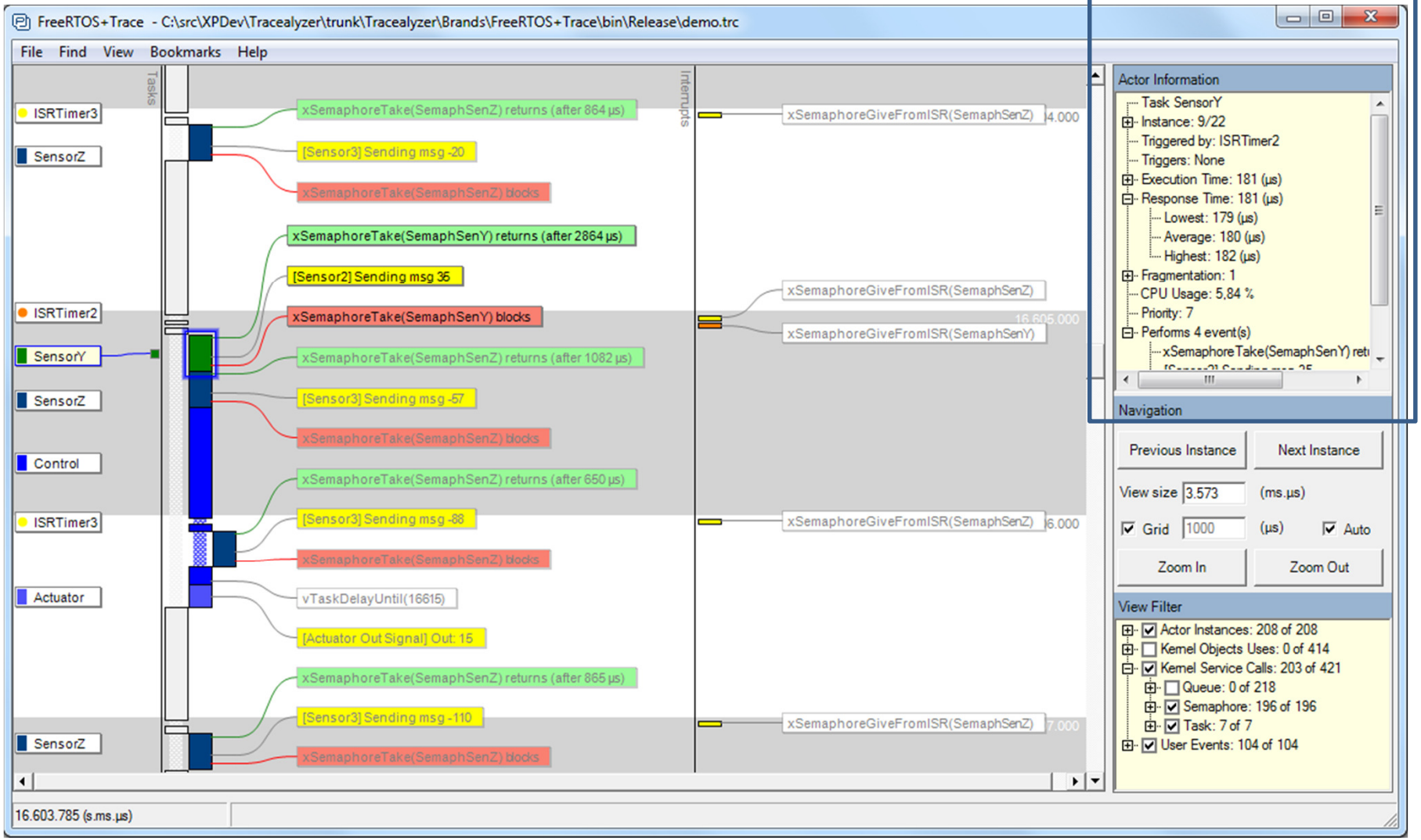
Interrupt routines (ISRs)

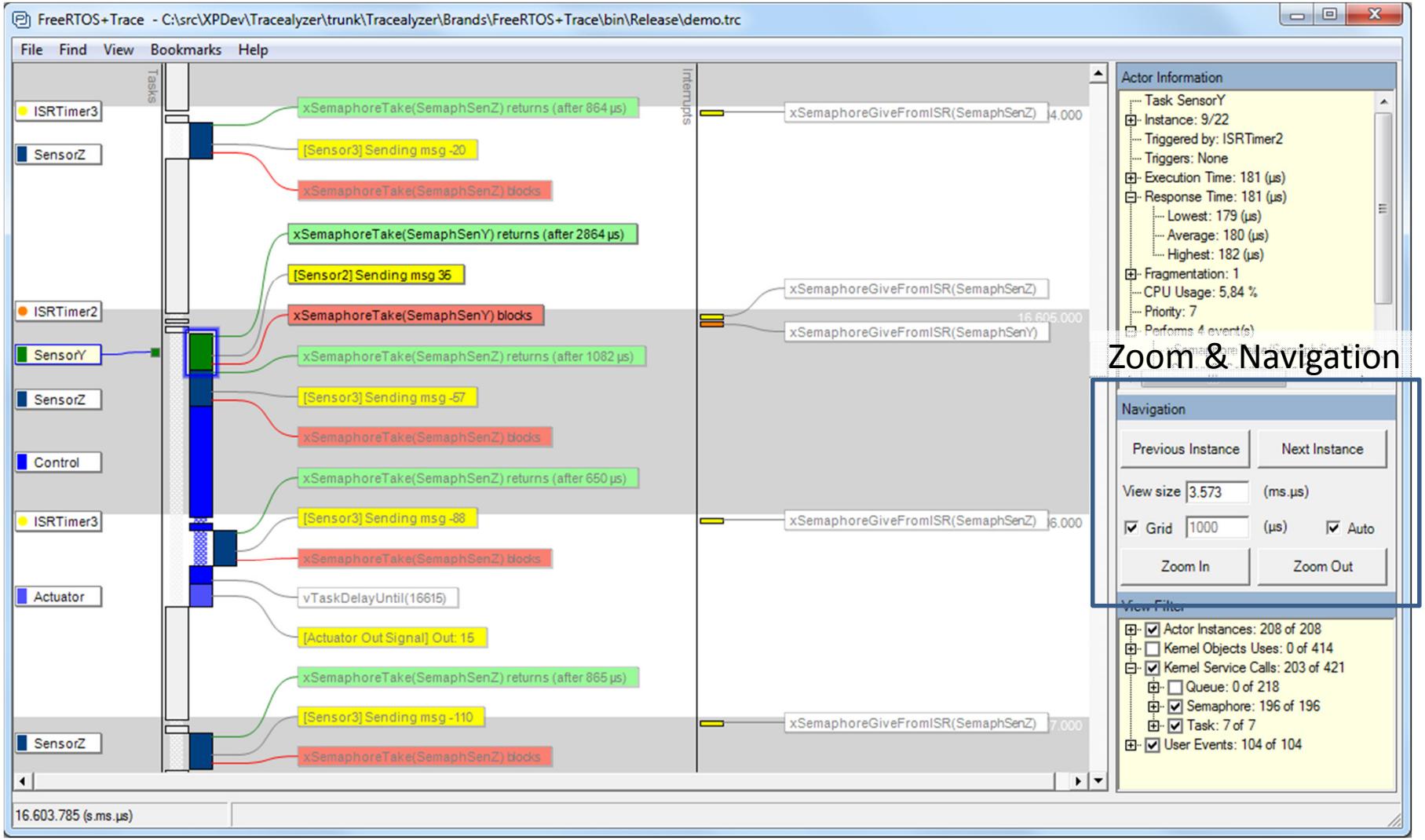


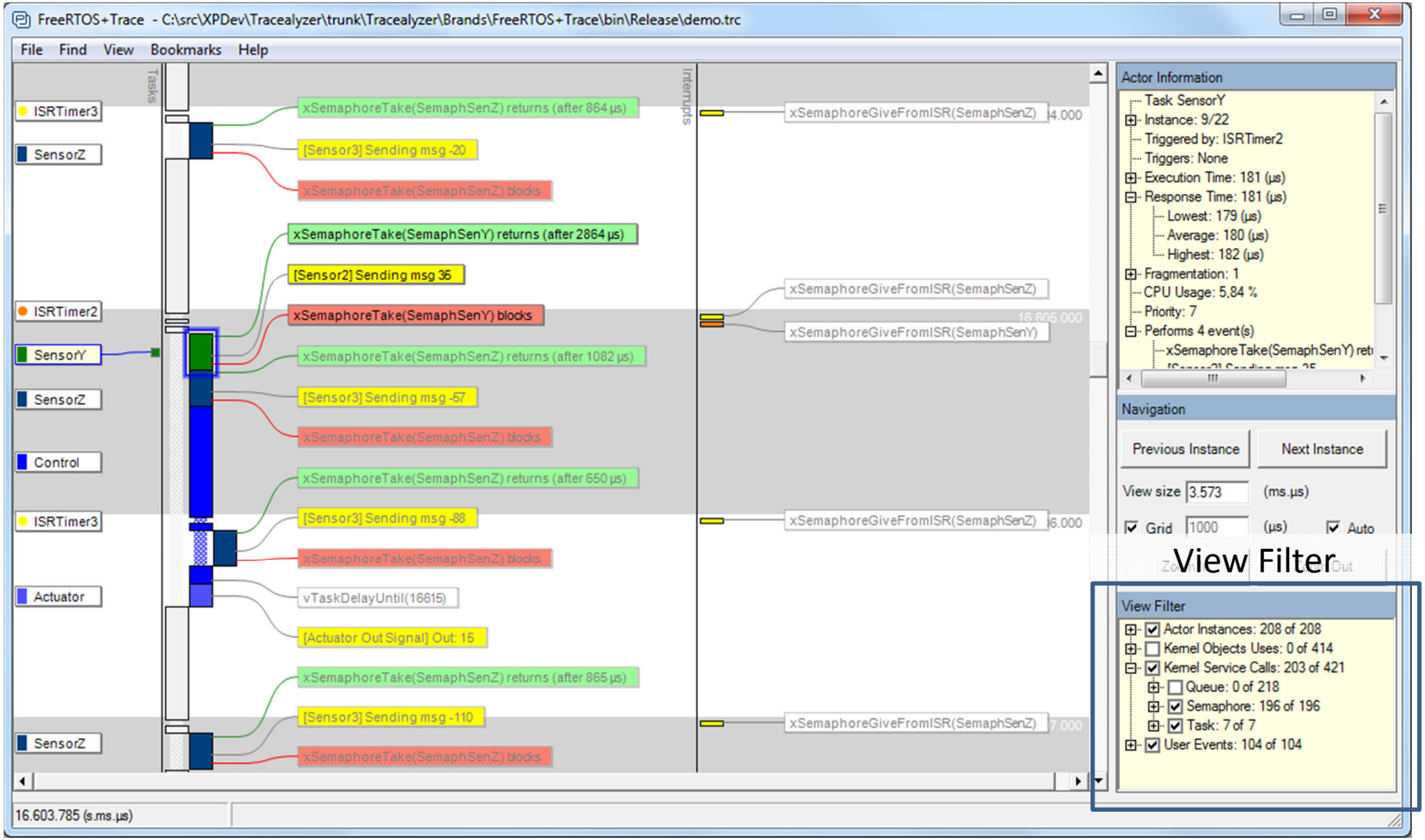
ISR system calls



Selected Actor Info




FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
[Sensor3] Sending msg -20
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenY) returns (after 2864 µs)
[Sensor2] Sending msg 36
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
[Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
[Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
[Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
[Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Zoom & Navigation
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
Zoom In
Zoom Out
View Filter
Actor Instances: 208 of 208
Kernel Objects Uses: 0 of 414
Kernel Service Calls: 203 of 421
Queue: 0 of 218
Semaphore: 196 of 196
Task: 7 of 7
User Events: 104 of 104
16.603.785 (s.ms.µs)


FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
[Sensor3] Sending msg -20
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenY) returns (after 2864 µs)
[Sensor2] Sending msg 36
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
[Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
[Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
[Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
[Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Performs 4 event(s)
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
View Filter
View Filter
Actor Instances: 208 of 208
Kernel Objects Uses: 0 of 414
Kernel Service Calls: 203 of 421
Queue: 0 of 218
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Task: 7 of 7
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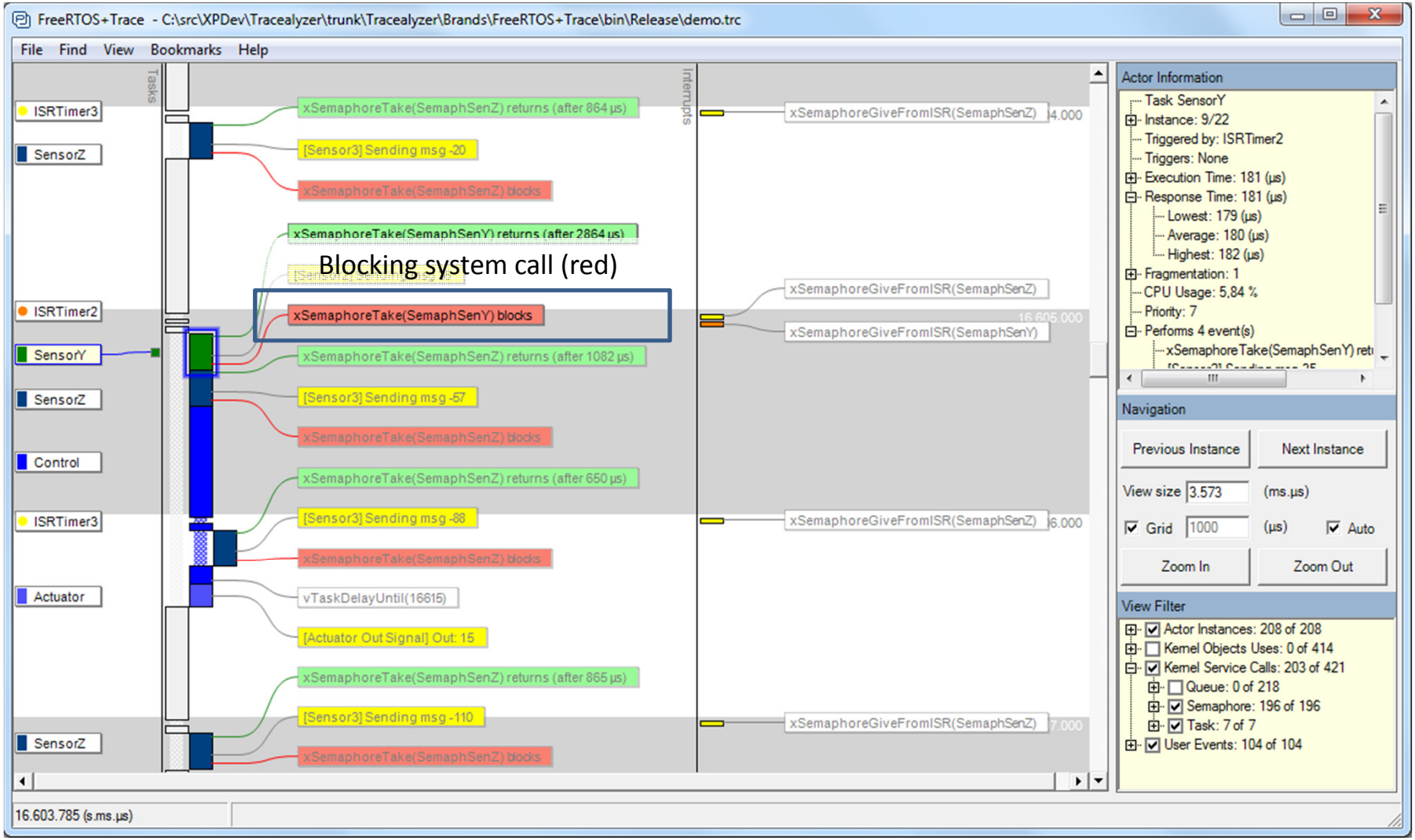
FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
[Sensor3] Sending msg -20
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenY) returns (after 2864 µs)
Blocking system call (red)
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
[Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
[Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
[Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
[Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
16.603.785 (s.ms.µs)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Performs 4 event(s)
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
Zoom In
Zoom Out
View Filter
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Queue: 0 of 218
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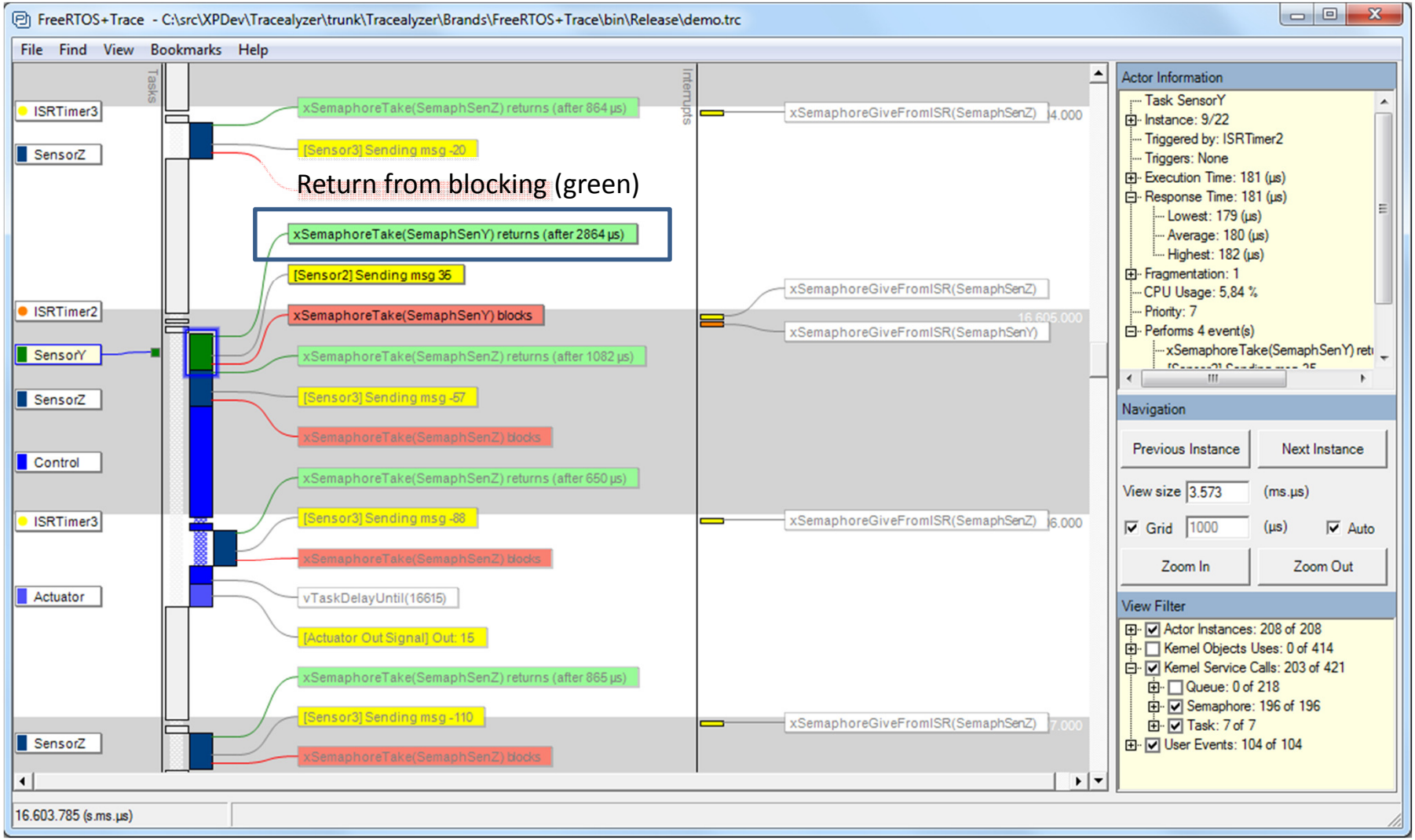
User Events: 104 of 104


FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
[Sensor3] Sending msg -20
Return from blocking (green)
xSemaphoreTake(SemaphSenY) returns (after 2864 µs)
[Sensor2] Sending msg 36
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
[Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
[Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
[Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
[Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Performs 4 event(s)
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
Zoom In
Zoom Out
View Filter
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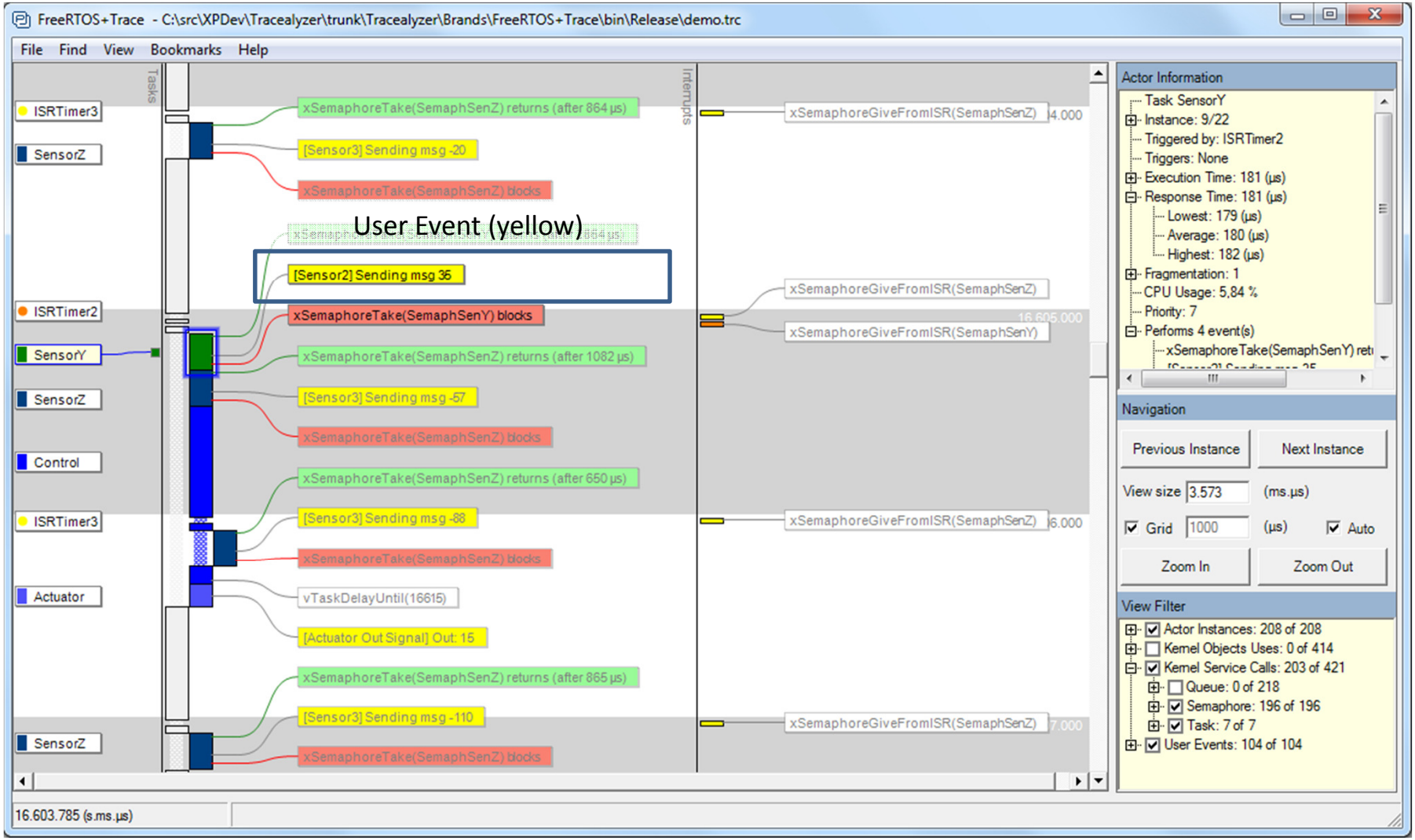
16.603.785 (s.ms.µs)


FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
[Sensor3] Sending msg -20
xSemaphoreTake(SemaphSenZ) blocks
User Event (yellow)
[Sensor2] Sending msg 36
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
[Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
[Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
[Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
[Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
16.603.785 (s.ms.µs)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Performs 4 event(s)
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
Zoom In
Zoom Out
View Filter
Actor Instances: 208 of 208
Kernel Objects Uses: 0 of 414
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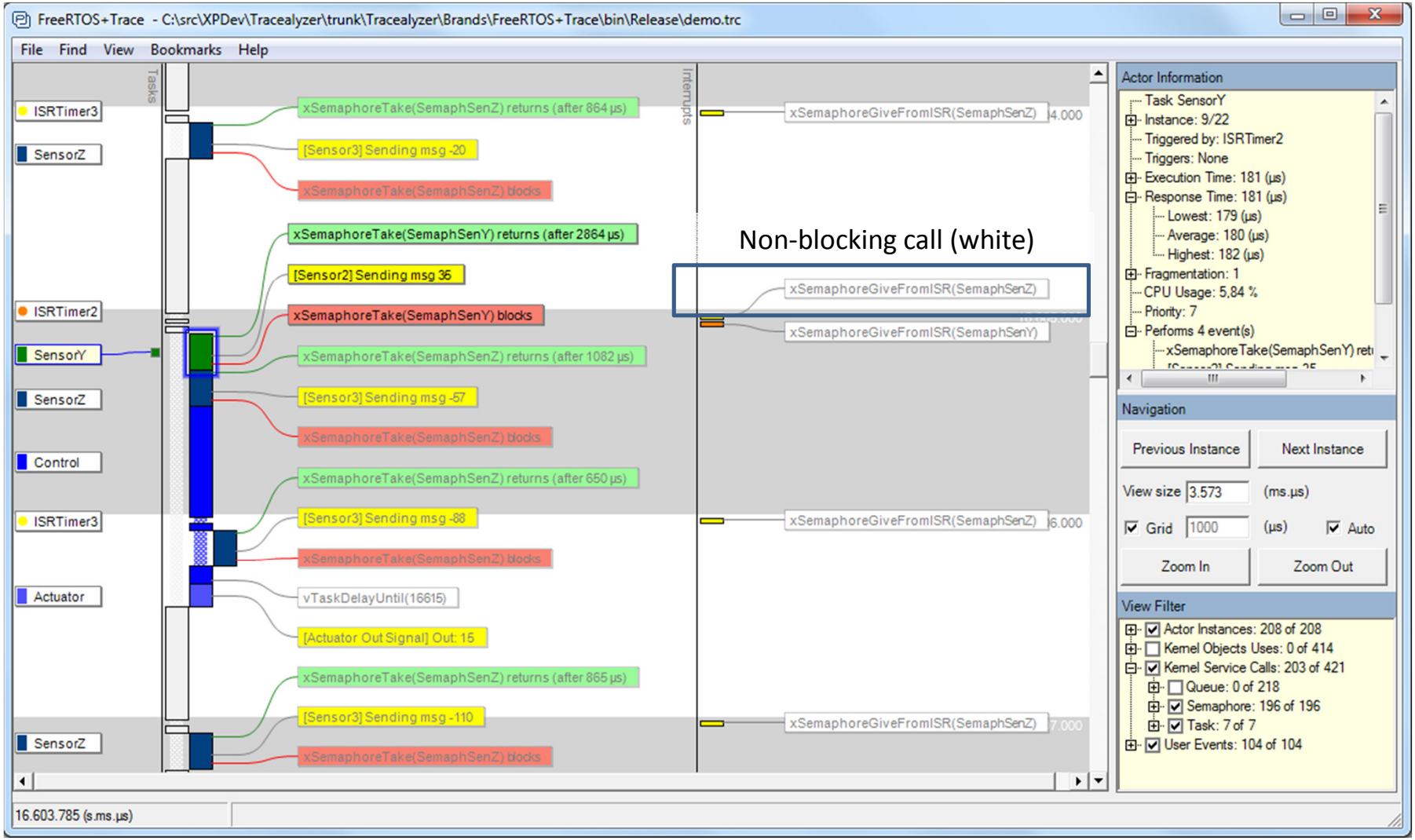
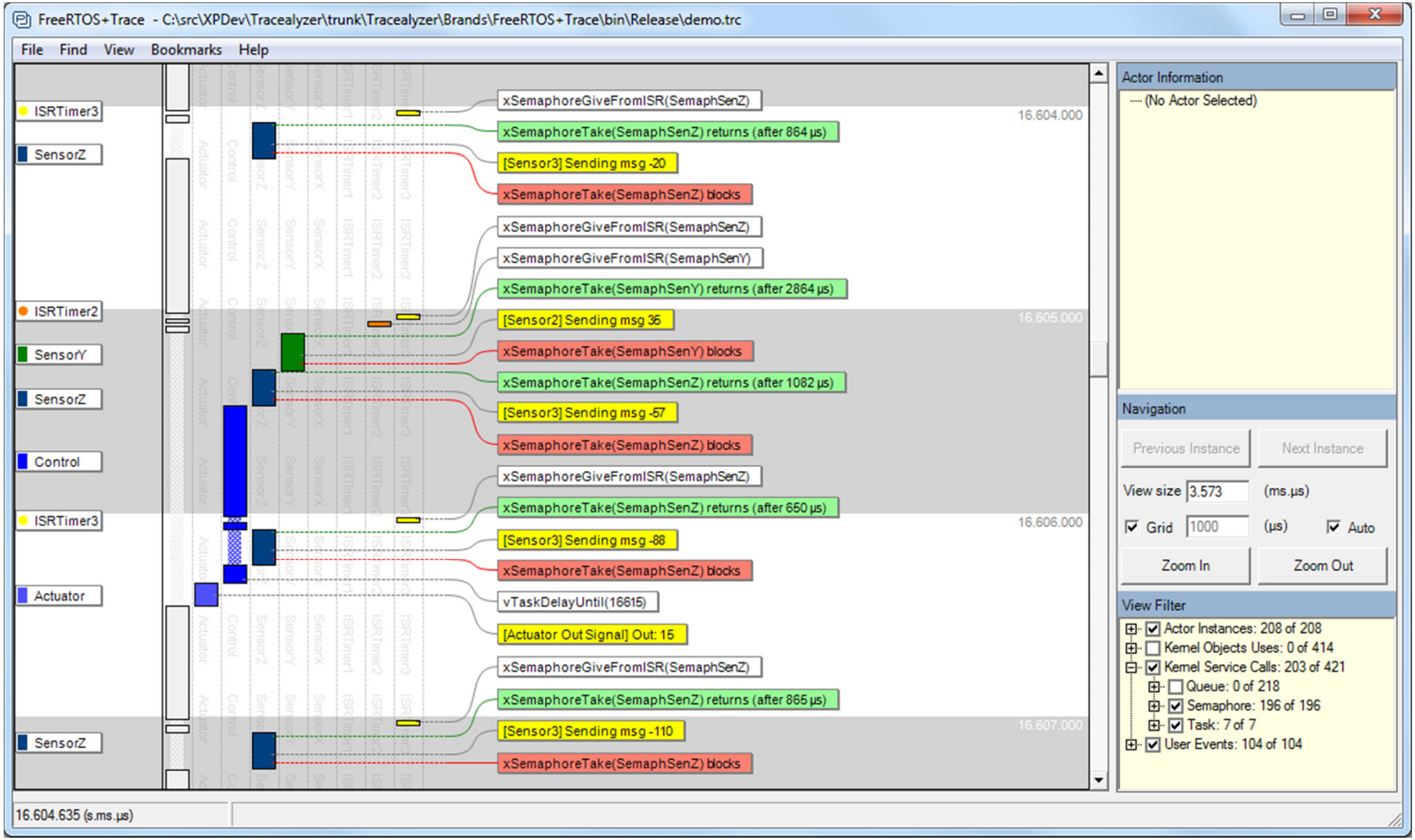
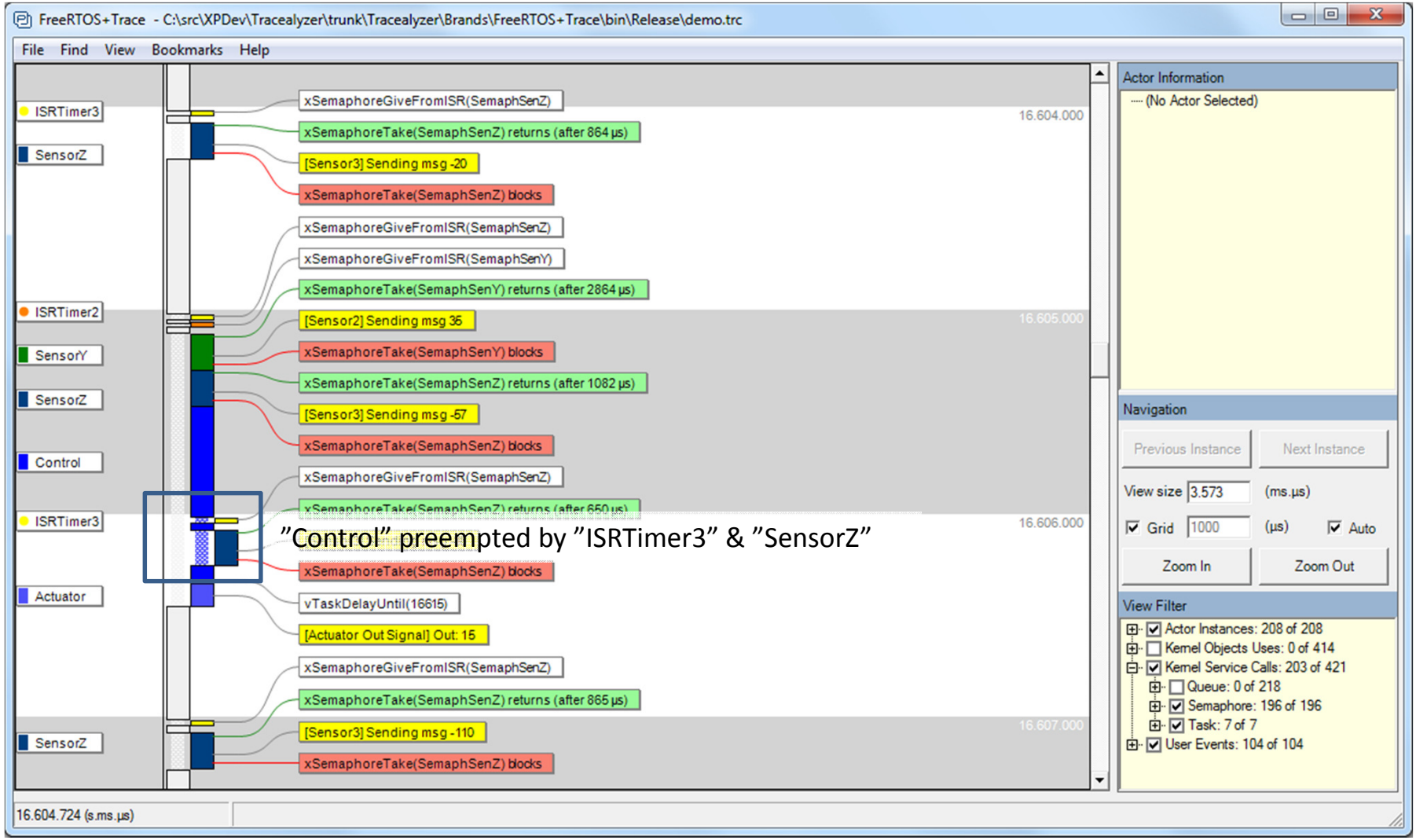
Queue: 0 of 218
Semaphore: 196 of 196
Task: 7 of 7
User Events: 104 of 104


FreeRTOS+Trace - C:\src\XPDev\Tracealyzer\trunk\Tracealyzer\Brands\FreeRTOS+Trace\bin\Release\demo.trc
File Find View Bookmarks Help
Tasks
Interrupts
ISRTimer3
SensorZ
ISRTimer2
SensorY
SensorZ
Control
ISRTimer3
Actuator
SensorZ
xSemaphoreTake(SemaphSenZ) returns (after 864 µs)
[Sensor3] Sending msg -20
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenY) returns (after 2864 µs)
[Sensor2] Sending msg 36
xSemaphoreTake(SemaphSenY) blocks
xSemaphoreTake(SemaphSenZ) returns (after 1082 µs)
[Sensor3] Sending msg -57
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreTake(SemaphSenZ) returns (after 650 µs)
[Sensor3] Sending msg -88
xSemaphoreTake(SemaphSenZ) blocks
vTaskDelayUntil(16615)
[Actuator Out Signal] Out: 15
xSemaphoreTake(SemaphSenZ) returns (after 865 µs)
[Sensor3] Sending msg -110
xSemaphoreTake(SemaphSenZ) blocks
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenY)
xSemaphoreGiveFromISR(SemaphSenZ)
xSemaphoreGiveFromISR(SemaphSenZ)
Non-blocking call (white)
Actor Information
Task SensorY
Instance: 9/22
Triggered by: ISRTimer2
Triggers: None
Execution Time: 181 (µs)
Response Time: 181 (µs)
Lowest: 179 (µs)
Average: 180 (µs)
Highest: 182 (µs)
Fragmentation: 1
CPU Usage: 5,84 %
Priority: 7
Performs 4 event(s)
Navigation
Previous Instance
Next Instance
View size 3.573 (ms.µs)
Grid 1000 (µs) Auto
Zoom In
Zoom Out
View Filter
Actor Instances: 208 of 208
Kernel Objects Uses: 0 of 414
Kernel Service Calls: 203 of 421
Queue: 0 of 218
Semaphore: 196 of 196
Task: 7 of 7
User Events: 104 of 104
16.603.785 (s.ms.µs)

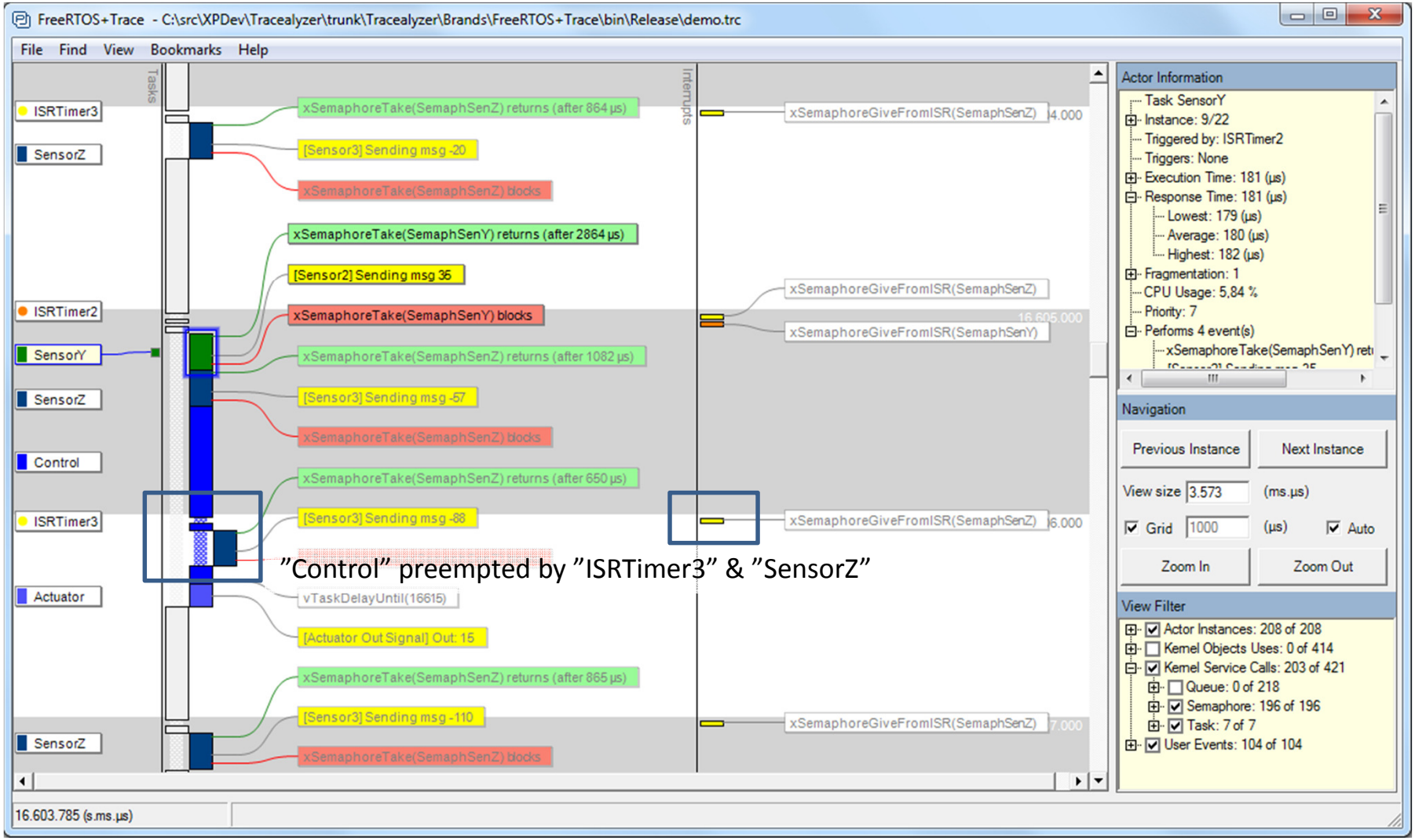
Gantt Mode - One column per task/ISR



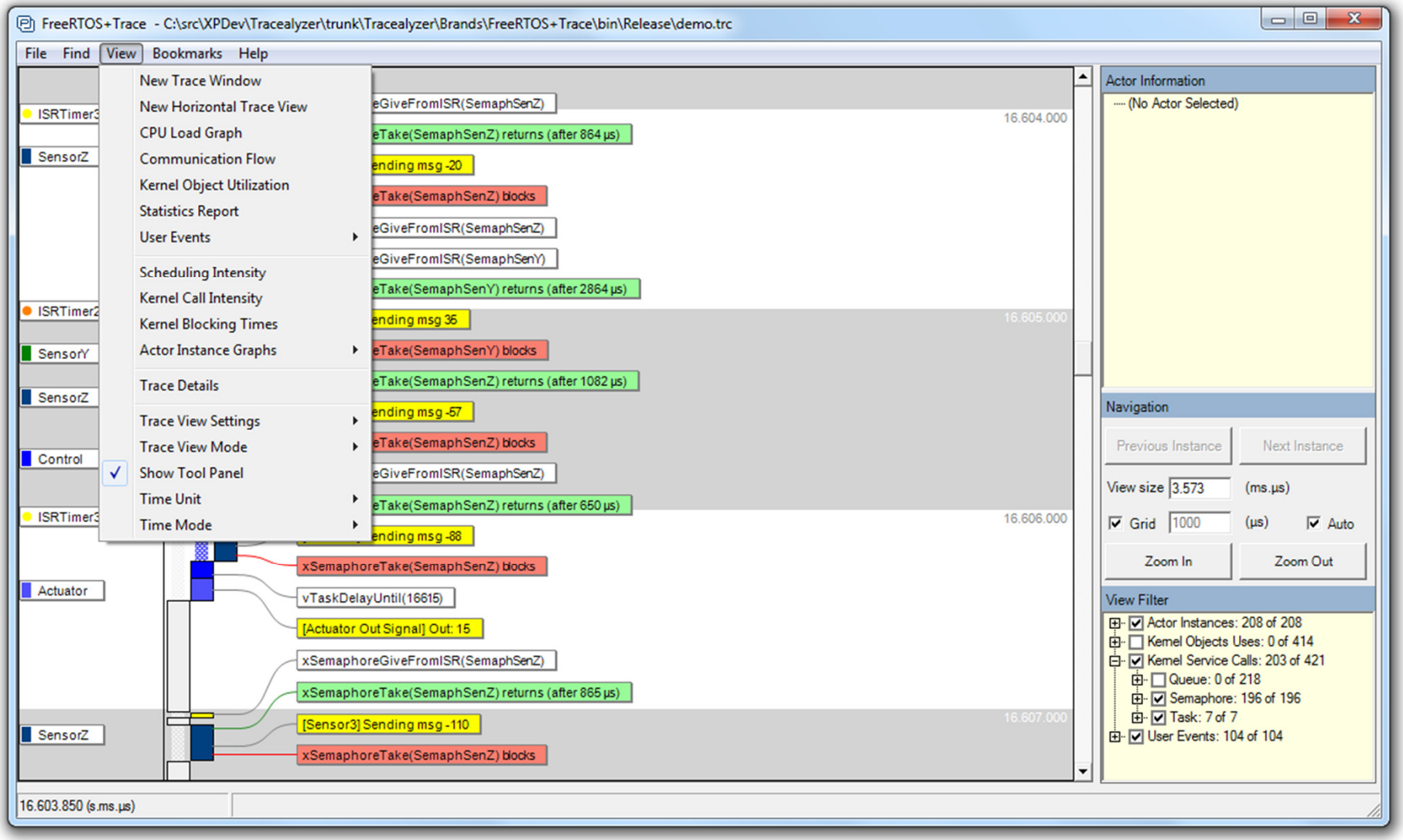
Merged Mode – Single Column for Better Sense of Order



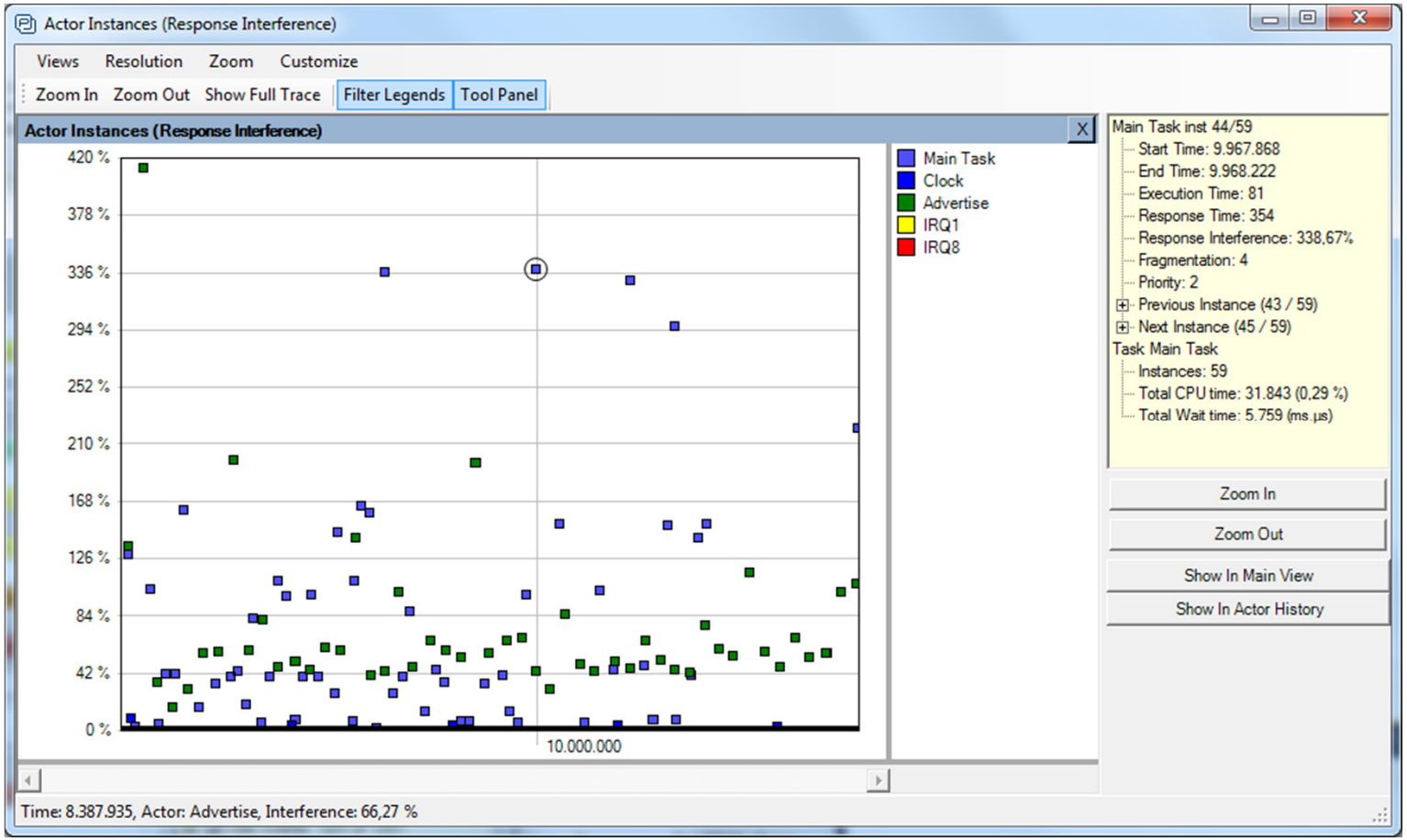
Split Mode – Tasks and ISRs in Separate Columns



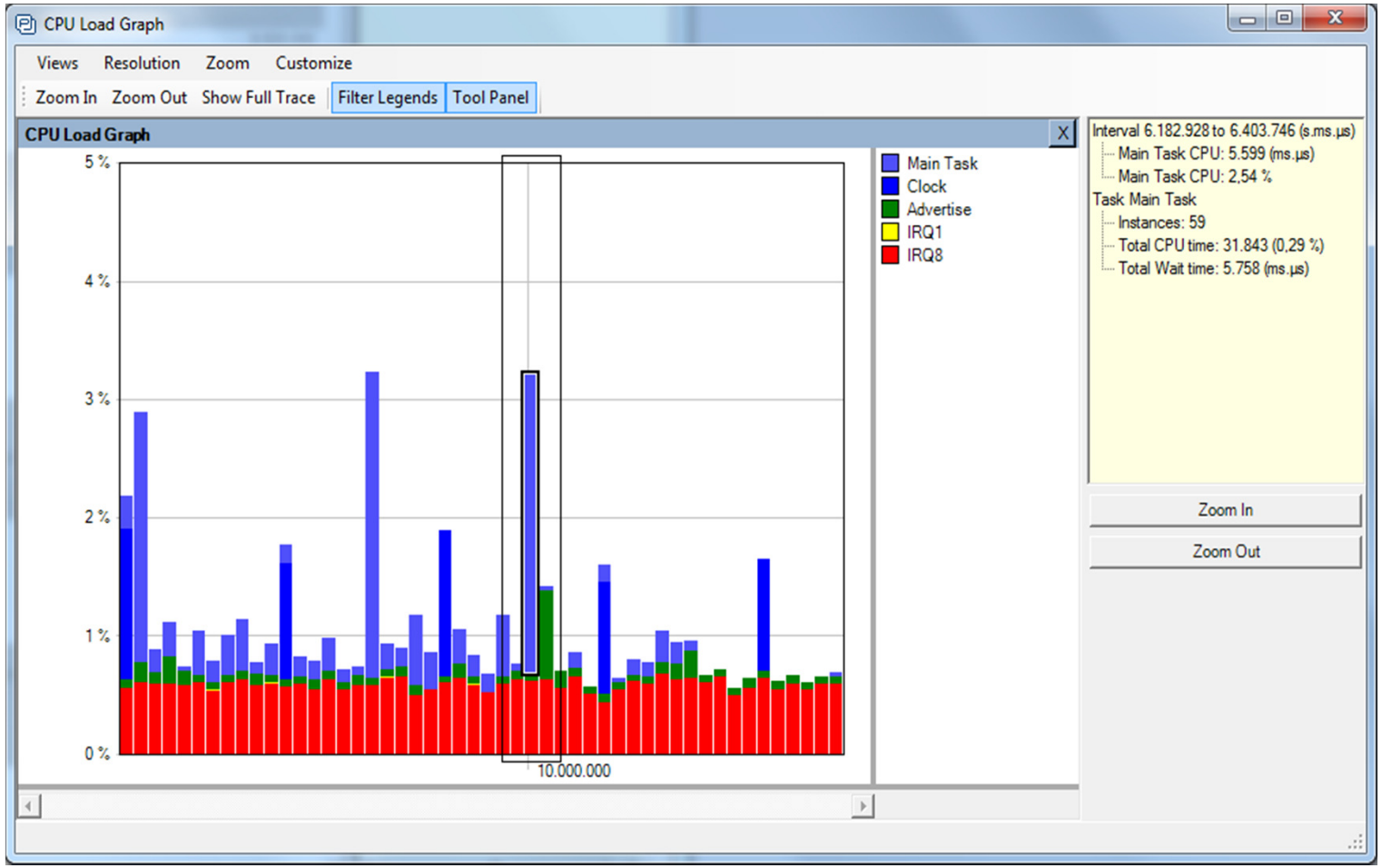
Additional supporting views (6 main types, 20+ views)



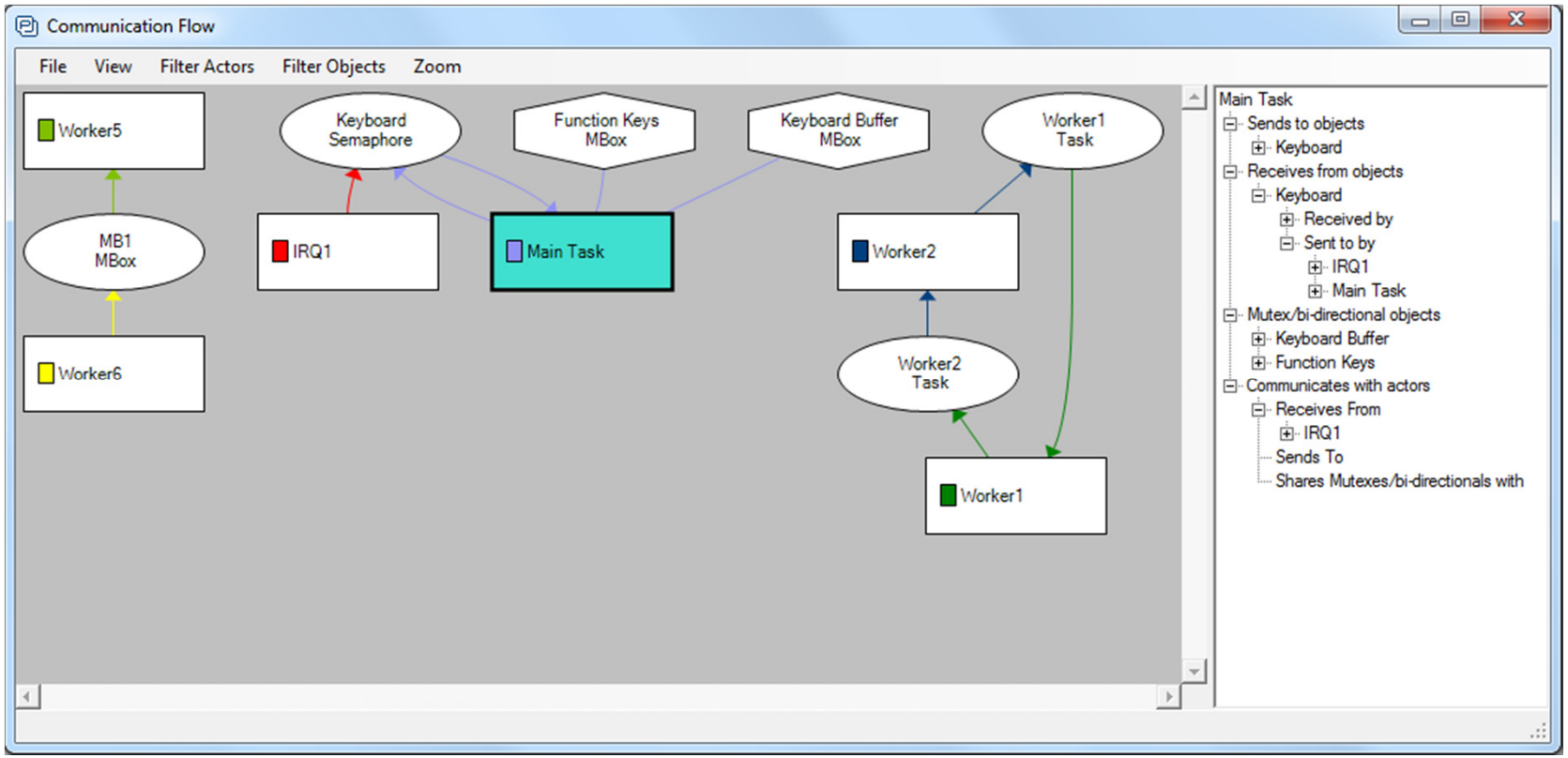
Timing Distribution Plots



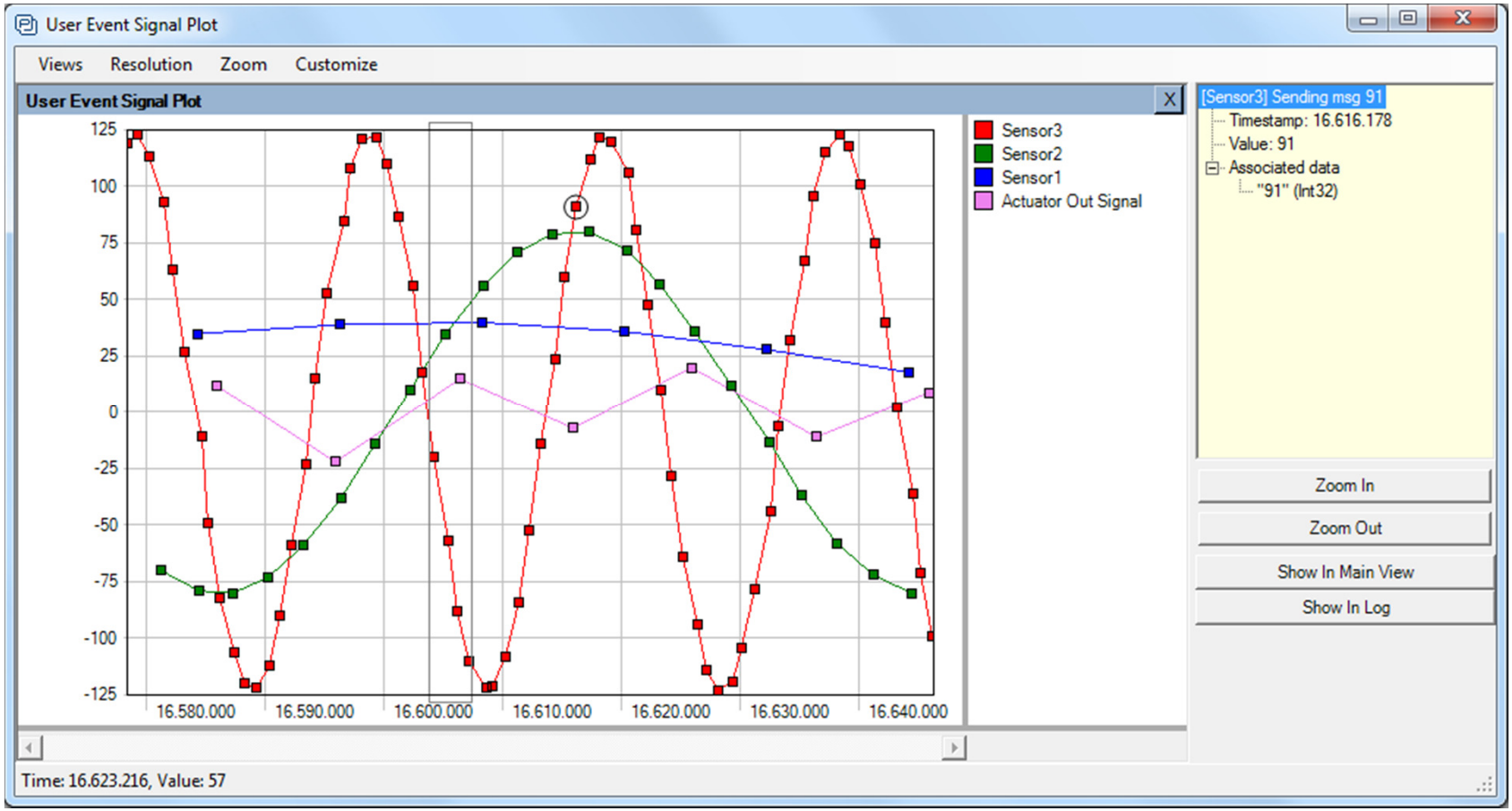
CPU Load Graph



Task Communication Flow



Application Data Plots



Views and Features in v2.3

- Trace Views
  - Main Trace View (Advanced)
  - Horizontal Trace View (Light)
- Advanced ”Finder”
- Communication Flow Graph
- Statistics Report
- Interval Graphs
  - CPU Load Graph
  - Scheduling Intensity
  - Kernel Call Intensity
- Event Listings
  - User Event Log
  - Kernel Object History
  - Actor Instances
- Data Plots
  - User Event Signal Plot
  - Kernel Blocking Time
  - Kernel Object Utilization
  - Actor Instance Graphs
    - Execution Time
    - Response Time
    - Wait Time
    - Response Interference
    - Periodicity
    - Separation (two versions)
    - Fragmentation (two versions)
- Combine Multiple Views
  - Independent
  - Synchronized

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