Public Preview Version

Software Trace Analysis Accelerated

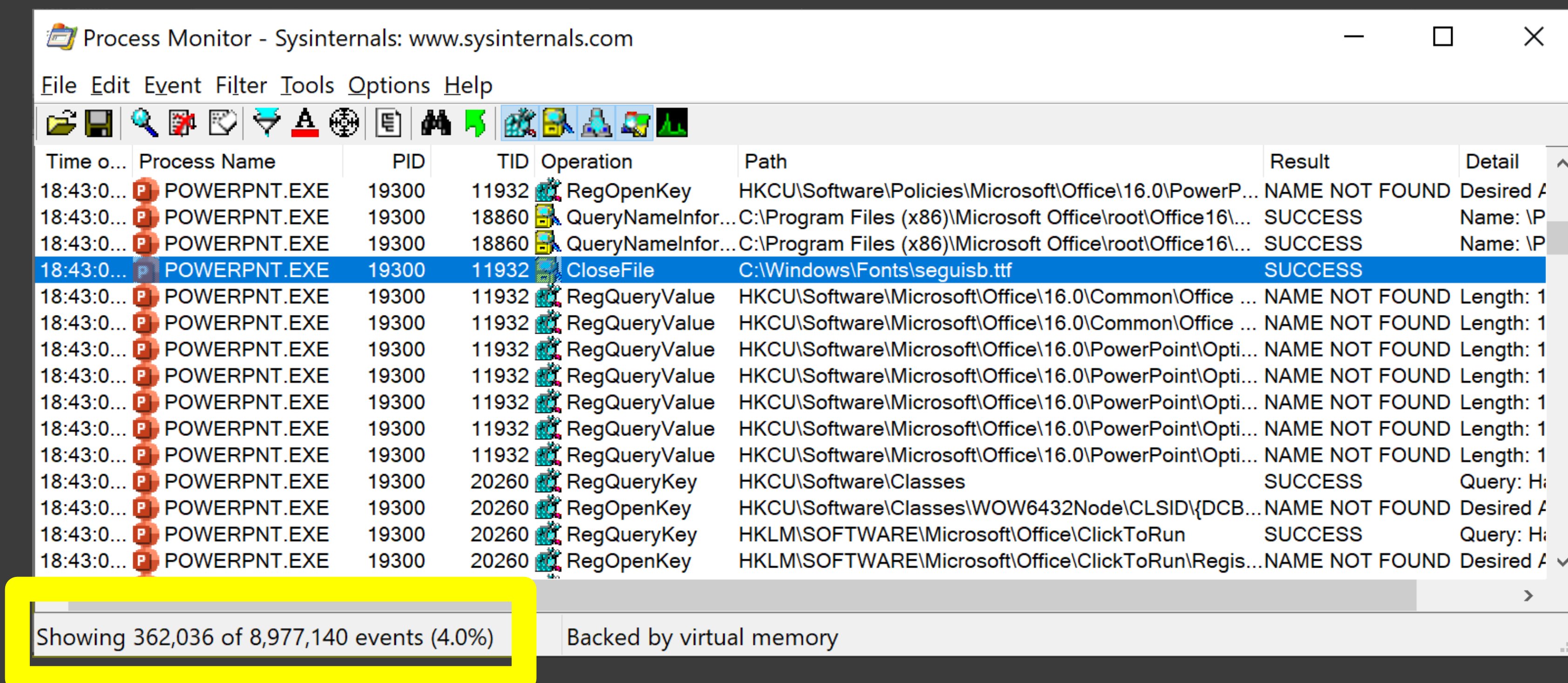
Revised Version

Part 1: Fundamentals and Basic Patterns

Dmitry Vostokov
Software Diagnostics Services

What's it all About?

- General trace and log analysis patterns
- Some examples are from Windows



Prerequisites

Basic OS troubleshooting

Training Goals

- Review tracing and logging fundamentals
- Learn basic trace and log analysis patterns

Training Principles

- Lots of pictures
- Pattern relationships

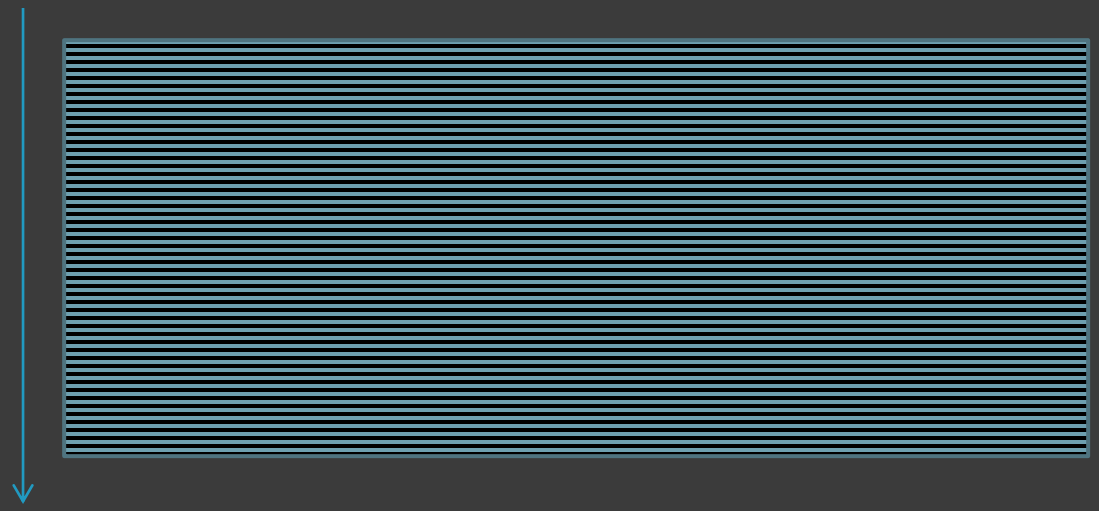
Part 1A: Fundamentals

Basic Concepts

- Software Trace (Log)
- Process
- Thread
- Adjoint Thread
- Component (Module or Source)
- File
- Function
- Message (Operation)
- Stack trace

Software Trace (Log)

- A sequence of formatted messages
- Arranged by time
- A narrative story

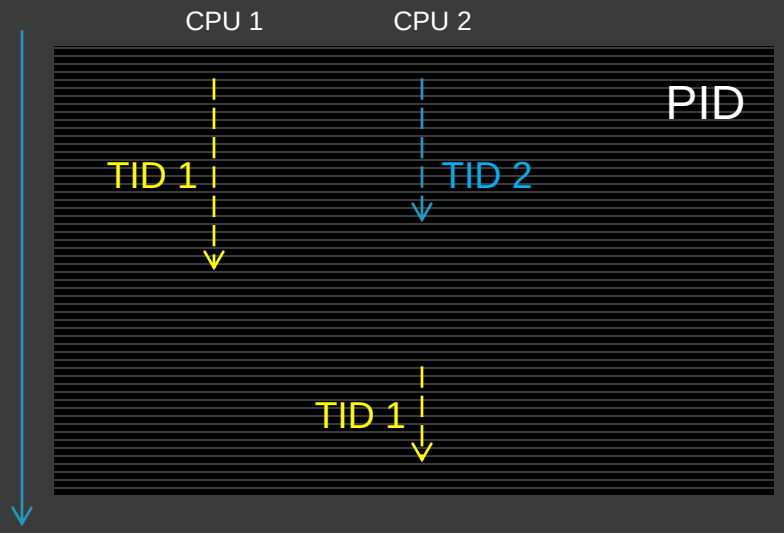


Process

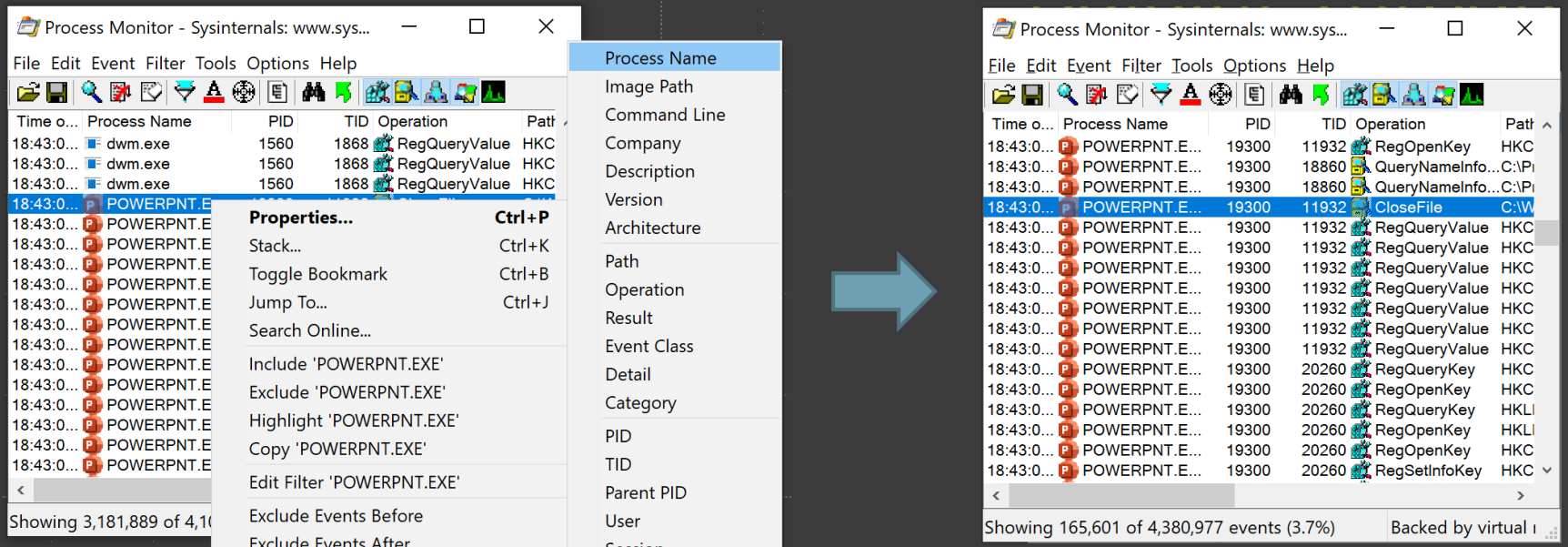
- PID
- Session
- Image Name
- Modules (DLLs)
- Examples:

Thread

- TID
- CPU
- Context



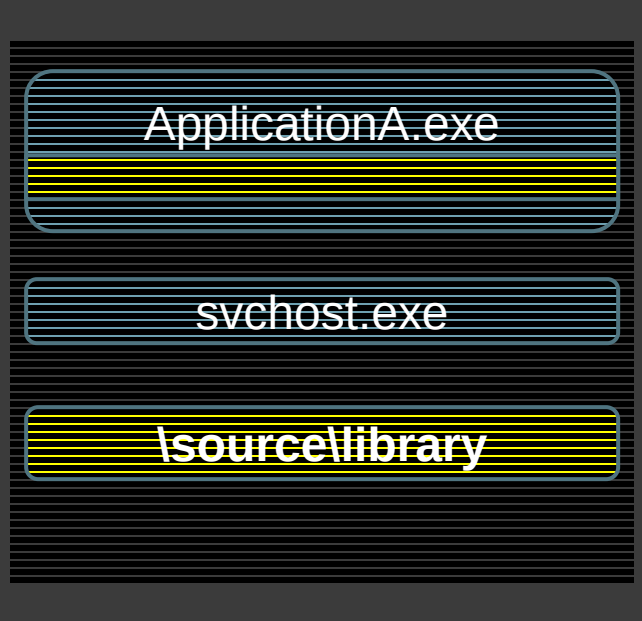
Adjoint Thread

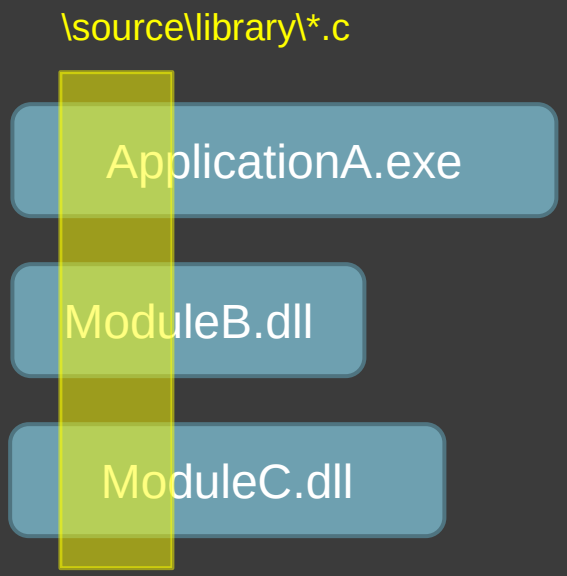


[Debugging TV Frame 0x14]

Component / Module / Source

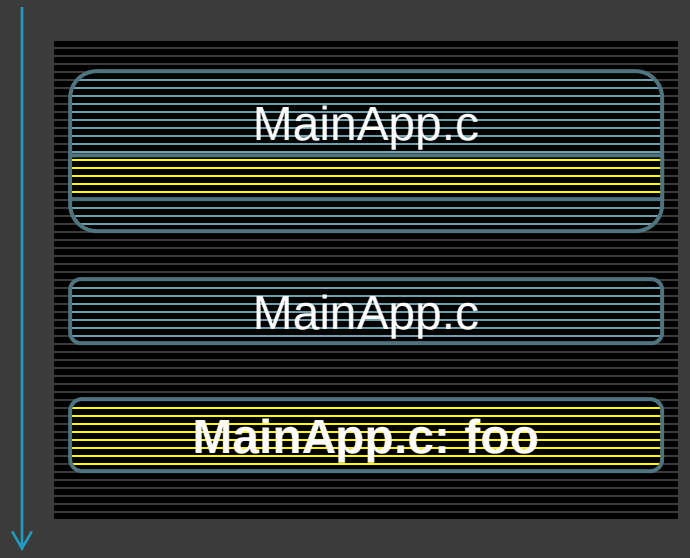
- Module Name
- Source Folder





File and Function

```
// MainApp.c
foo () {
  trace("foo: entry");
  // do stuff
  trace("foo: exit");
}
```

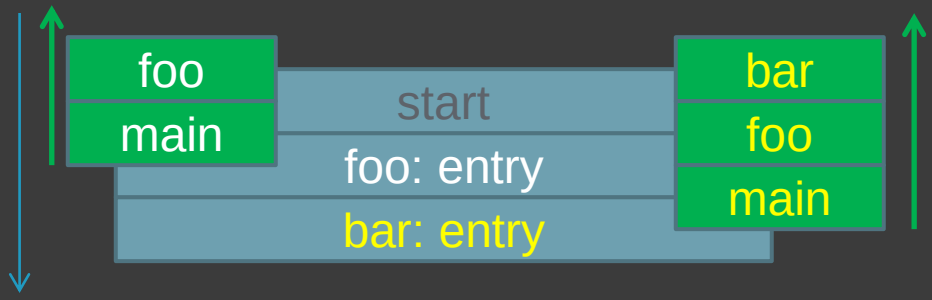


Trace Message

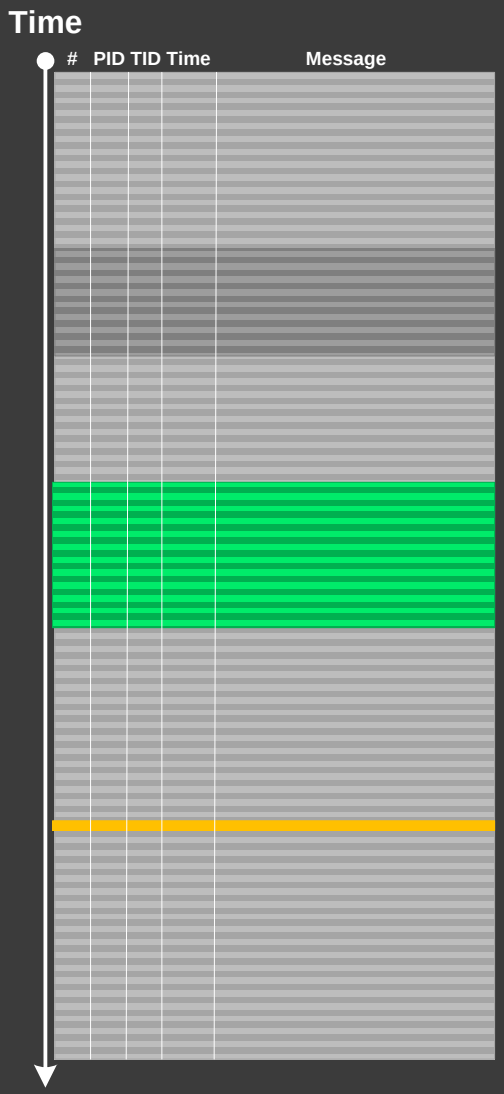
```
// MainApp.c
foo () {
  trace(“foo: entry”);
  int result = bar();
  trace(“bar result: 5”);
  trace(“foo: exit”);
}
```

Stack Trace

```
// MainApp.c
main() {
  trace("start");
  foo();
}

foo() {
  trace("foo: entry");
  bar();
}

bar() {
  trace("bar: entry");
  // do stuff
}
```



Minimal Trace Graphs




```
No Module  PID  TID  Date      Time         Message
-------------------------------------------------------
1  ModuleA 4280 1736 5/28/2012 08:53:50.496 Trace message 1
2  ModuleB 6212 6216 5/28/2012 08:53:52.876 Trace message 2
[…]
```

Common Trace Formats

- ETW
- CSV
- Free
- Mixed

Pattern-Driven Analysis

Diagnostic Pattern: a common recurrent identifiable problem together with a set of recommendations and possible solutions to apply in a specific context.

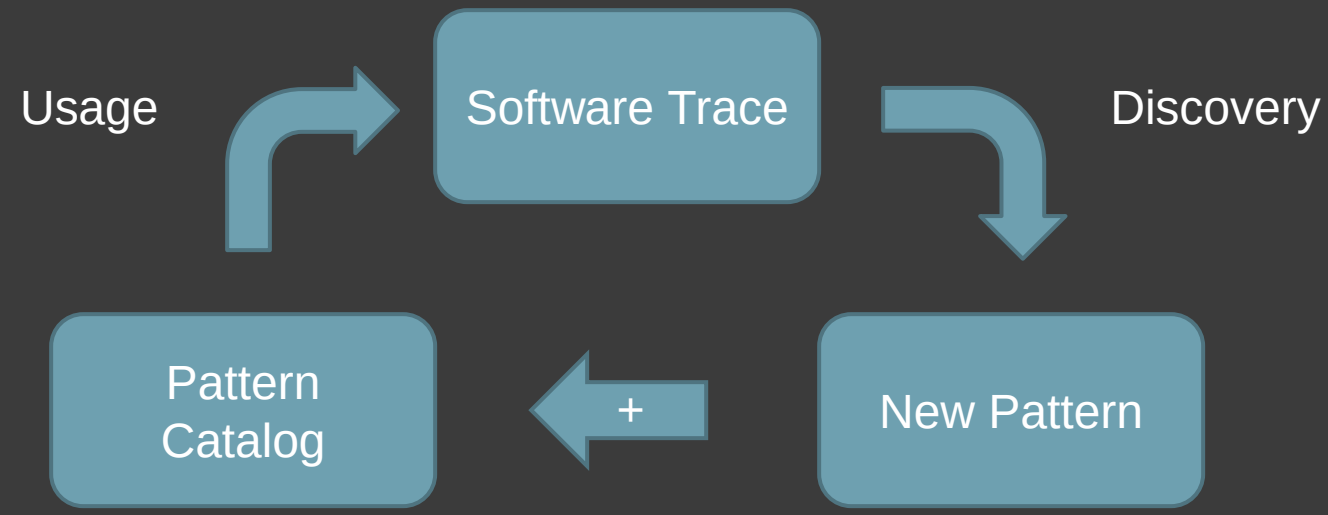
Diagnostic Problem: a set of indicators (symptoms, signs) describing a problem.

Diagnostic Analysis Pattern: a common recurrent analysis technique and method of diagnostic pattern identification in a specific context.

Diagnostics Pattern Language: common names of diagnostic and diagnostic analysis patterns. The same language for any operating system: Windows, Mac OS X, Linux, ...

Checklist: http://www.dumpanalysis.org/blog/index.php/2011/03/10/software-trace-analysis-checklist/
Patterns: http://www.dumpanalysis.org/blog/index.php/trace-analysis-patterns/

Pattern-Based Analysis

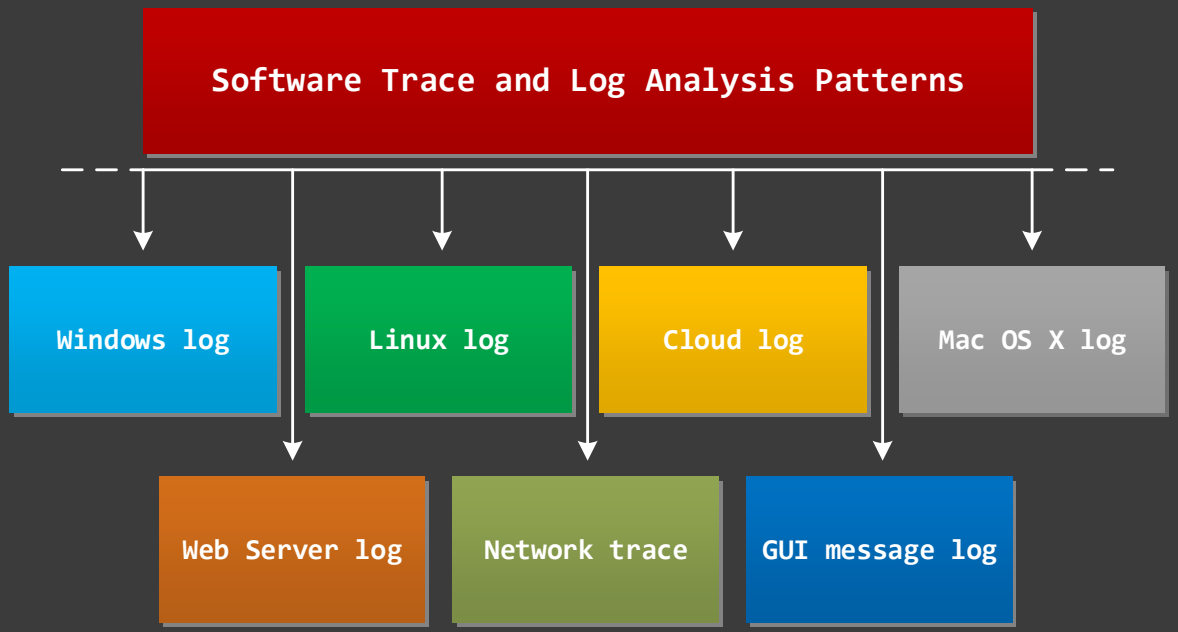


Pattern Hierarchy

- Domain Independent

from IBM mainframes to mobile and embedded computers

- Domain Specific



Pattern Classification

- Vocabulary
- Error
- Trace as a Whole
- Large Scale
- Activity
- Message
- Block
- Trace Set

Part 1B: Basic Patterns

Vocabulary Patterns

- Basic Facts
- Vocabulary Index

Basic Facts

Related Patterns
Vocabulary Index

- Problem Description

Application disappears after launch

- Software Trace

```
PID    Message
---------------------------------
…
3f6    Create process AppA: PID 4a5
4a5    AppA loads DLLC
…
3f6    Create process AppB: PID 5b8
5b8    AppB loads DLLD
…
```

Basic Facts Taxonomy

- Functional Facts

Example: Expected a dialog to enter data

- Non-functional Facts

Example: CPU consumption 100%

- Identification Facts

Application name, PID, user name

Vocabulary Index

- Problem Description

A **user Test123** **authentication** failed

basic fact index

- Narrowing:

Related Patterns

Basic Facts
Activity Region

Error Patterns

- Error Message
- Exception Stack Trace
- False Positive Error
- Periodic Error ↓*
- Error Distribution

* '↓' sign means that a pattern involves time dependency

Error Message

- Explicit errors
- Implicit errors
- WinDbg command !error

Related Patterns
False Positive Error
Periodic Error
Error Distribution
Adjoint Thread
Data Flow

```
0:000> !error c0000017
Error code: (NTSTATUS) 0xc0000017 (3221225495) - {Not Enough Quota}  Not enough
    virtual memory or paging file quota is available to complete the specified
    operation.

0:000> !error 5
Error code: (Win32) 0x5 (5) - Access is denied.
```

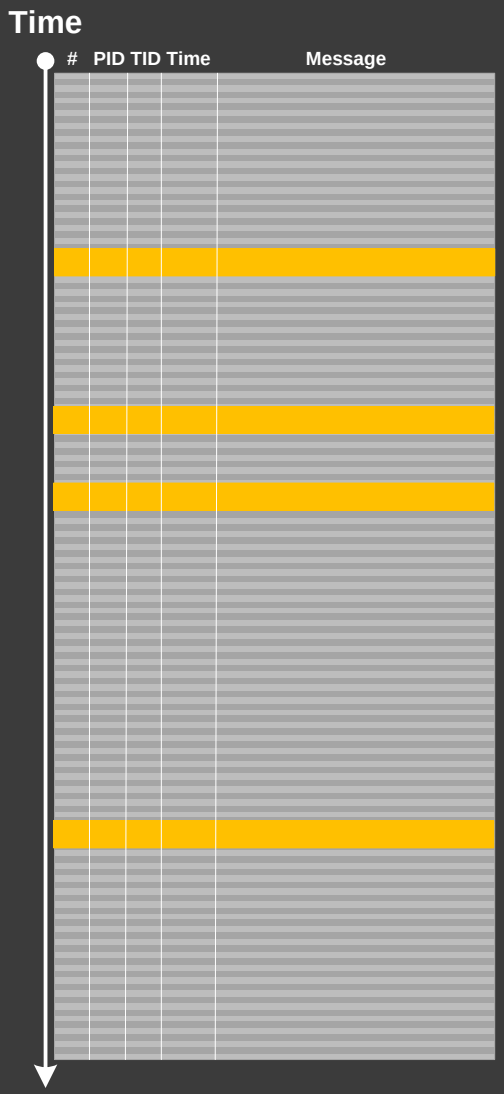
Exception Stack Trace

Related Patterns

Error Message

```
No     PID  TID  Message
-----------------------
[…]
265799 8984 4216 ComponentA.Store.GetData threw exception: 'System.Reflection.TargetInvocationException: DCOM connection to
server failed with error: 'Exception from HRESULT: 0x842D0001' --> System.Runtime.InteropServices.COMException (0x842D0001):
Exception from HRESULT: 0x842D0001
265800 8984 4216 === Exception Stack Trace ===
265801 8984 4216 at System.Runtime.Remoting.Proxies.RealProxy.HandleReturnMessage(IMessage reqMsg, IMessage retMsg)
265802 8984 4216 at System.Runtime.Remoting.Proxies.RealProxy.PrivateInvoke(MessageData& msgData, Int32 type)
265803 8984 4216 at ComponentA.Store.GetData(Byte[] pKey)
265804 8984 4216 at ComponentA.App.EnumBusinessObjects()
[…]
```

Periodic Error ↓




```
No    PID  TID  Message
----------------------
[…]
36495 1788 2250 MyClass::Init: Cannot open connection “Client ID: 310”, status=5
[…]
[…]
36883 1788 1986 MyClass::Init: Cannot open connection “Client ID: 612”, status=5
[…]
```

Related Patterns

Error Message
Error Distribution
False Positive Error
Message Invariant

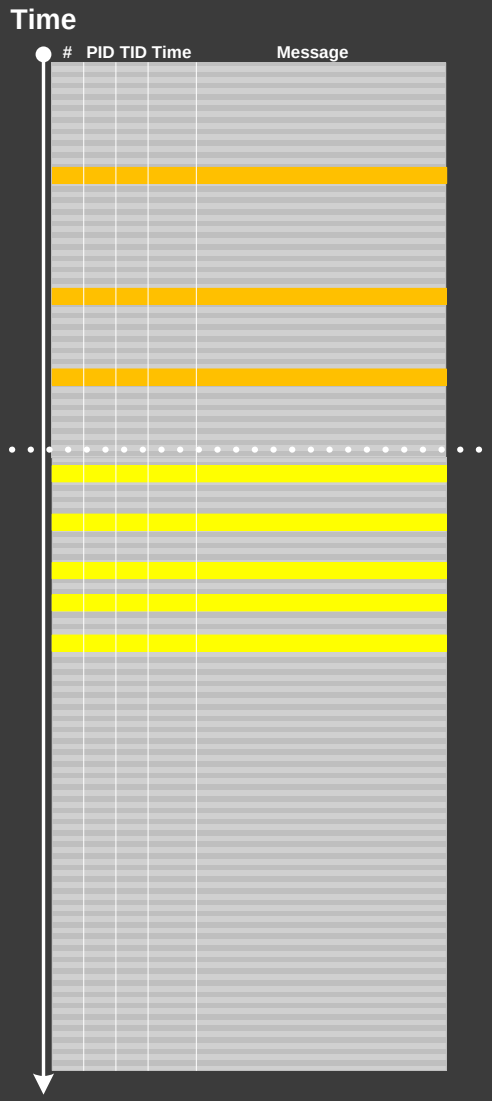
False Positive Error

- Expected errors
- Not relevant to our problem
- Implementation details

Related Patterns

Error Message
Master Trace
Activity Region

Error Distribution



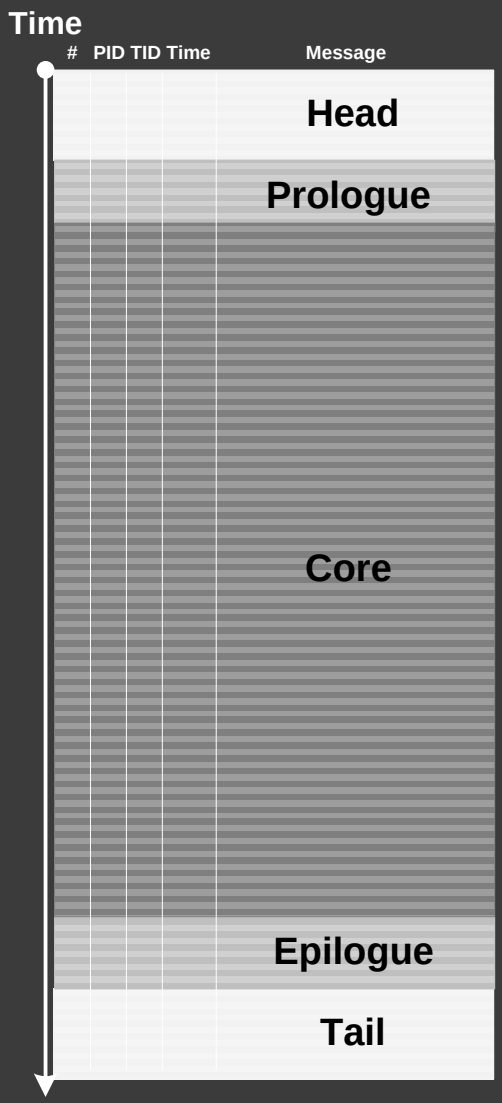
Related Patterns

Partition
Activity Region

Trace as a Whole

- Partition
- Circular Trace ↓
- Message Density
- Message Current ↓
- Trace Acceleration ↓
- No Trace Metafile
- Empty Trace
- Missing Component
- Guest Component
- Truncated Trace ↓
- Visibility Limit
- Sparse Trace

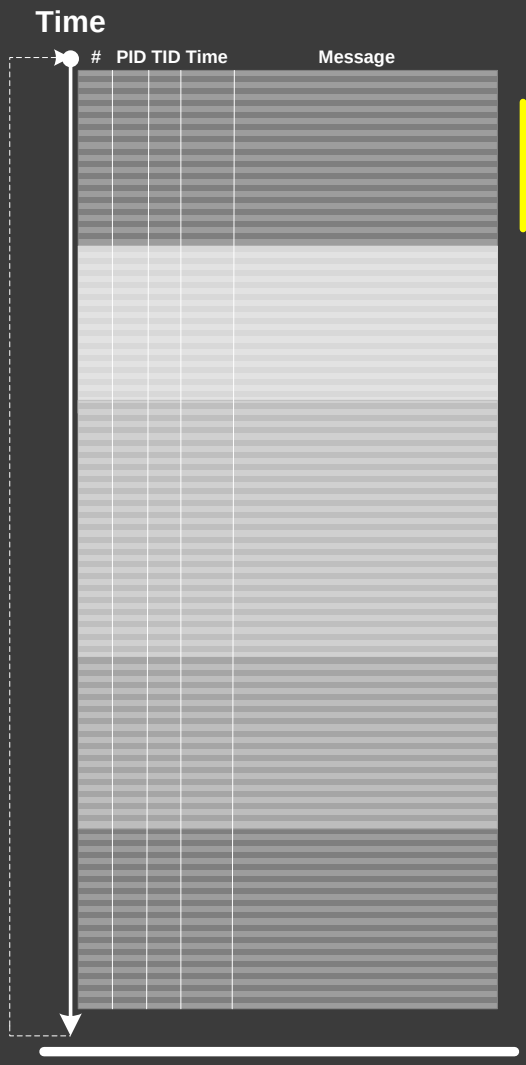
Partition



Related Patterns

Significant Event
Truncated Trace
Adjoint Thread

Circular Trace ↓

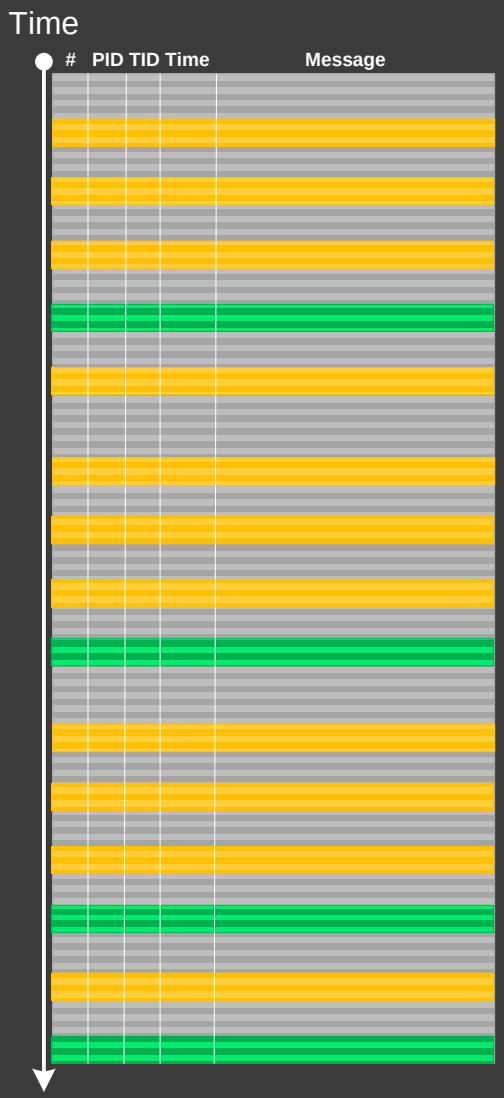


No	Module	PID	TID	Date	Time	Message
1	ModuleA	4280	1736	5/28/2009	08:53:50.496	Trace message 1
2	ModuleB	6212	6216	5/28/2009	08:53:52.876	Trace message 2
3	ModuleA	4280	4776	5/28/2009	08:54:13.537	Trace message 3
[…]						
3799	ModuleA	4280	3776	5/28/2009	09:15:00.853	Trace message 3799
3800	ModuleA	4280	1736	5/27/2009	09:42:12.029	Trace message 3800
[…]						
579210	ModuleA	4280	4776	5/28/2009	08:53:35.989	Trace message 579210

Related Patterns

Focus of Tracing

Message Density



Related Patterns
Intra-correlation **Focus of Tracing** **Relative Density** **Partition**

$$D_1 > D_2$$

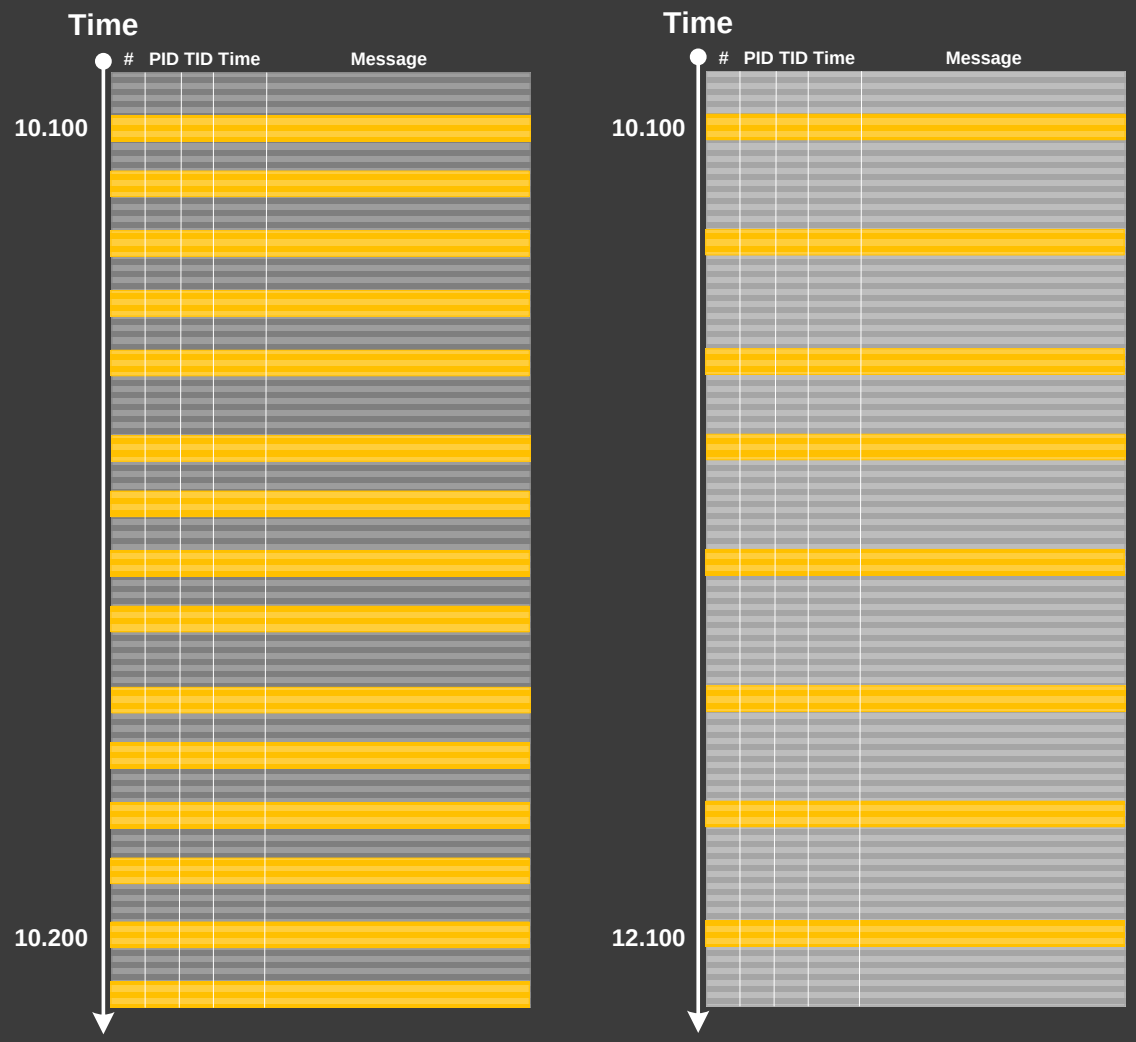
Similar relative density for 2 traces may shows correlation:

$$D_{11} / D_{21} = D_{12} / D_{22}$$

For correlated messages different densities from 2 traces may show different partition or system conditions:

$$D_{11} >> D_{12}$$

Message Current ↓

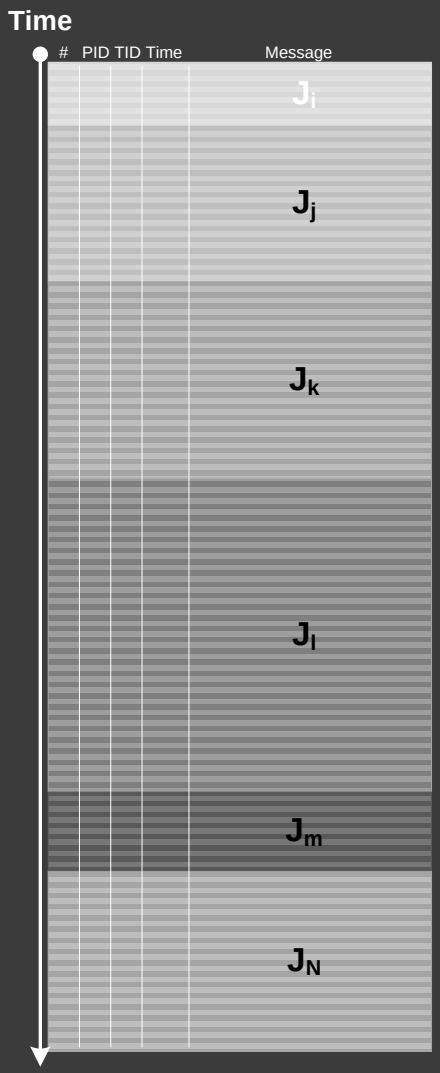


Related Patterns

Significant Event
Activity Region
Message Density

$J_1 > J_2$

Trace Acceleration ↓



Related Patterns

Activity Region
Message Current
Thread of Activity
Adjoint Thread of Activitiy

Message current $\mathbf{J_i} < \mathbf{J_j}$, $i < j < N$

Partial message currents:

with respect to TID X $J_{k(TID=x)}$

with respect to PID Y $J_{k(PID=y)}$

with respect to PID X and TID Z $J_{k(PID=y\ \&\ TID=z)}$

No Trace Metafile

Related Patterns
Thread of Activity

```
#     Module  PID  TID  Time         Message
-----------------------------------------
[…]
21372 dllA    2968 5476 3:55:10.004 Calling foo()
21373 Unknown 2968 5476 3:55:10.004 Unknown GUID=A1E38F24-613D-4D71-B9F5-… (No Format Information found).
21374 Unknown 2968 5476 3:55:10.004 Unknown GUID=A1E38F24-613D-4D71-B9F5-… (No Format Information found)
21375 Unknown 2968 5476 3:55:10.004 Unknown GUID=A1E38F24-613D-4D71-B9F5-… (No Format Information found)
21376 Unknown 2968 5476 3:55:10.004 Unknown GUID=A1E38F24-613D-4D71-B9F5-… (No Format Information found)
21377 Unknown 2968 5476 3:55:10.004 Unknown GUID=A1E38F24-613D-4D71-B9F5-… (No Format Information found)
21378 dllA    2968 5476 3:55:10.004 Calling bar()
[…]
```

Possible patterns to detect:

- Circular Trace
- Message Density
- Message Current
- Discontinuity
- Time Delta
- Trace Acceleration

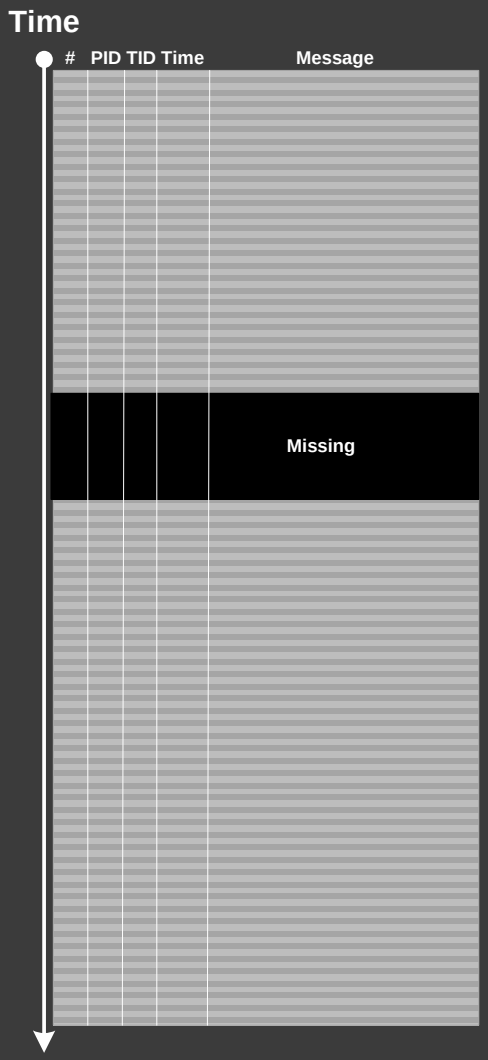
Empty Trace

- Small file size
- Very few trace messages

Always open a trace before sending to someone else

Related Patterns
Truncated Trace **No Activity** **Missing Component**

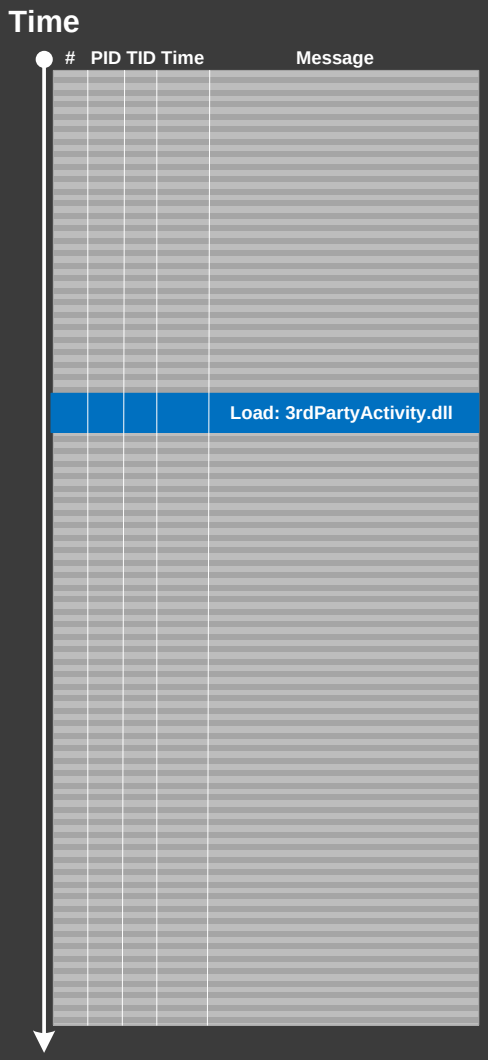
Missing Component



Related Patterns

Discontinuity
Inter-Correlation
No Activity

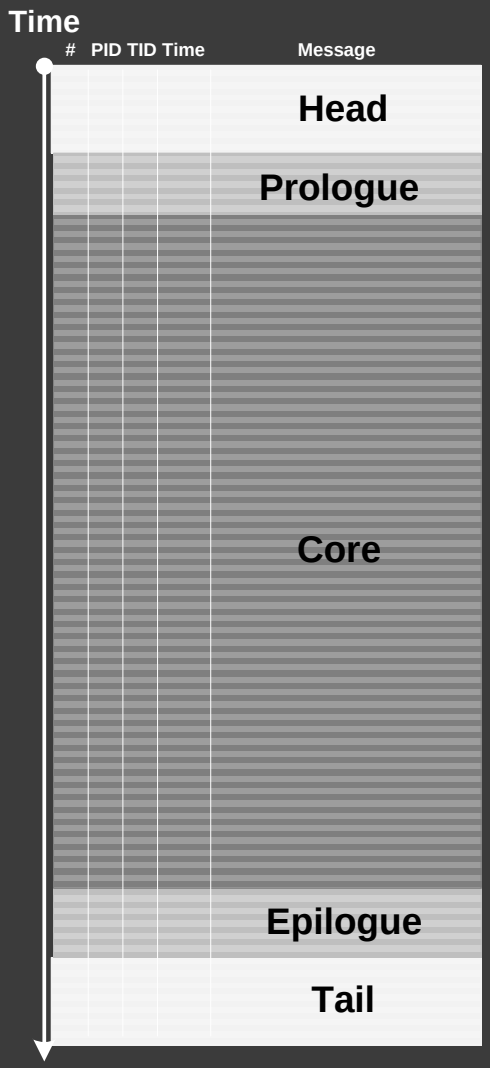
Guest Component

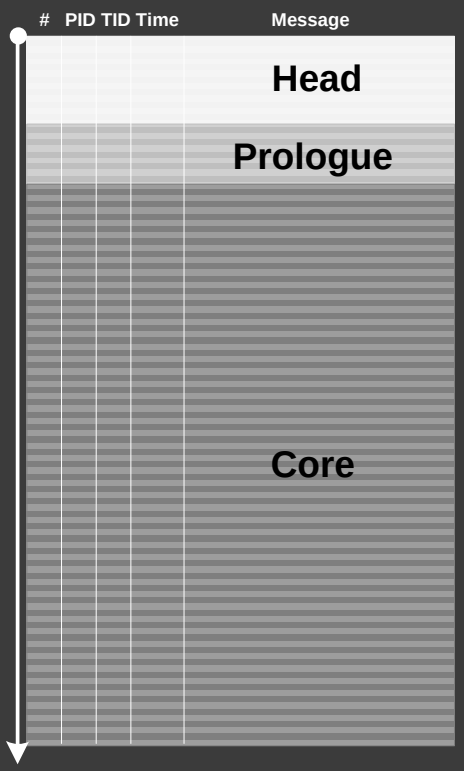


Related Patterns

Missing Component

Truncated Trace ↓

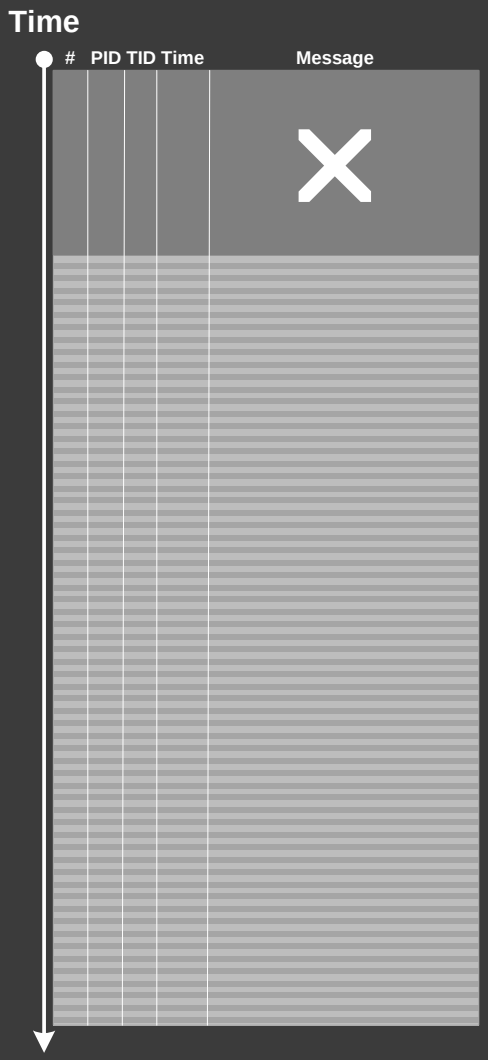




Related Patterns

Partition
Anchor Messages
Missing Component

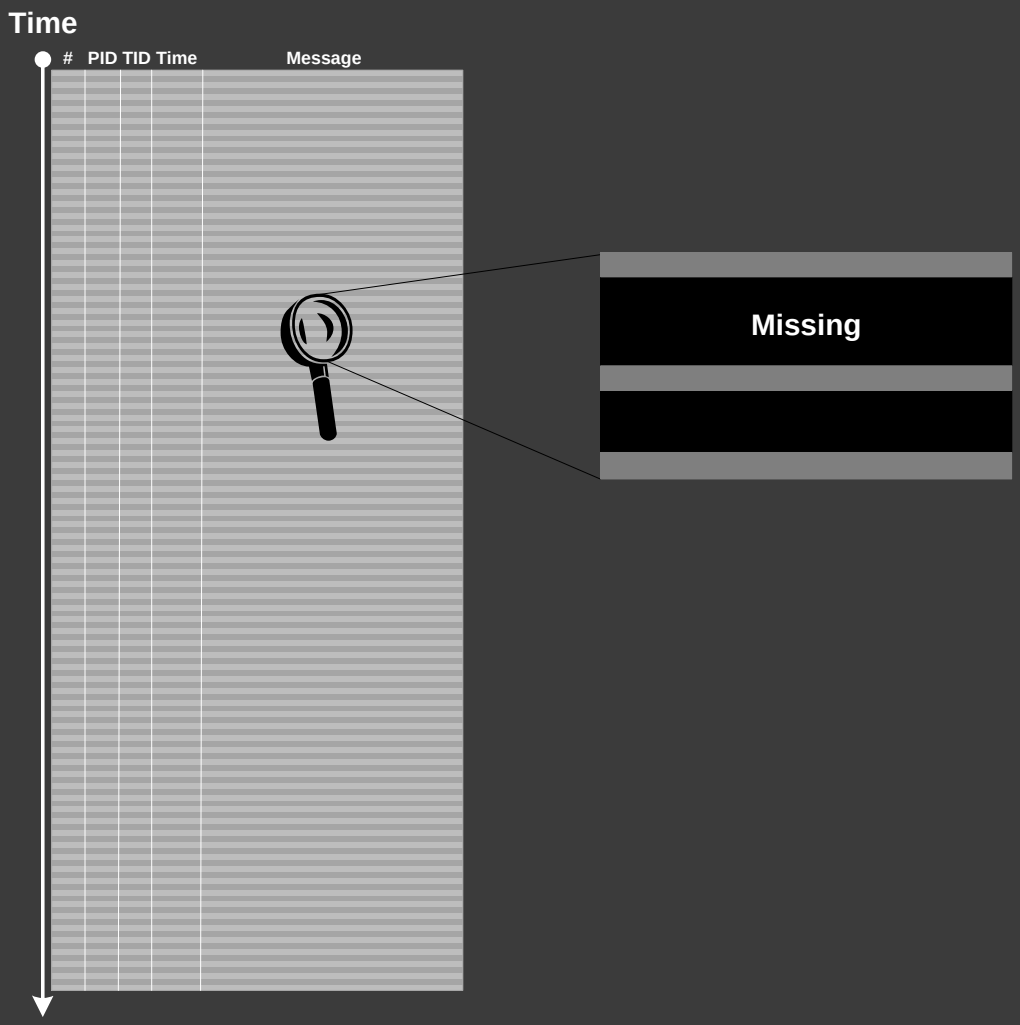
Visibility Limit



Related Patterns

Truncated Trace
Missing Component
Sparse Trace

Sparse Trace



Related Patterns

Missing Component
Visibility Limit

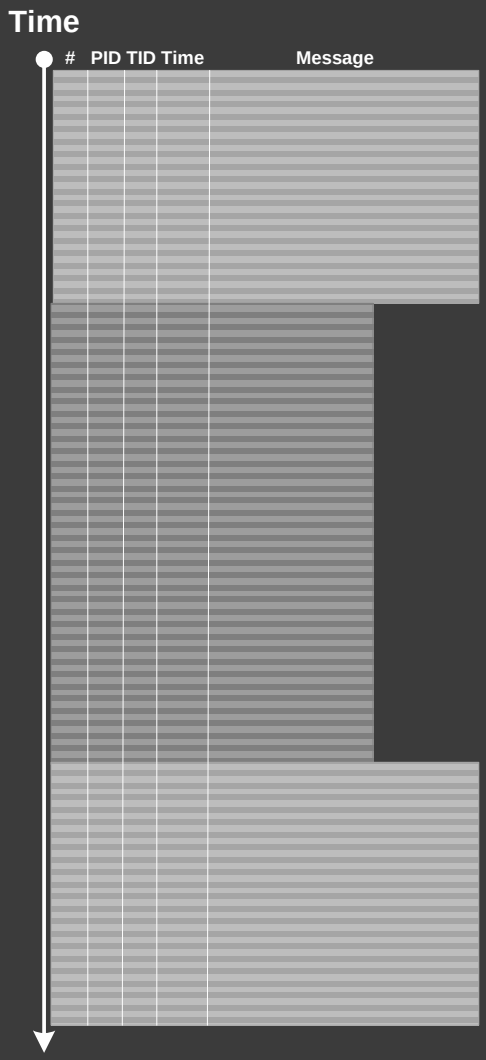
PLOT

Large Scale Patterns

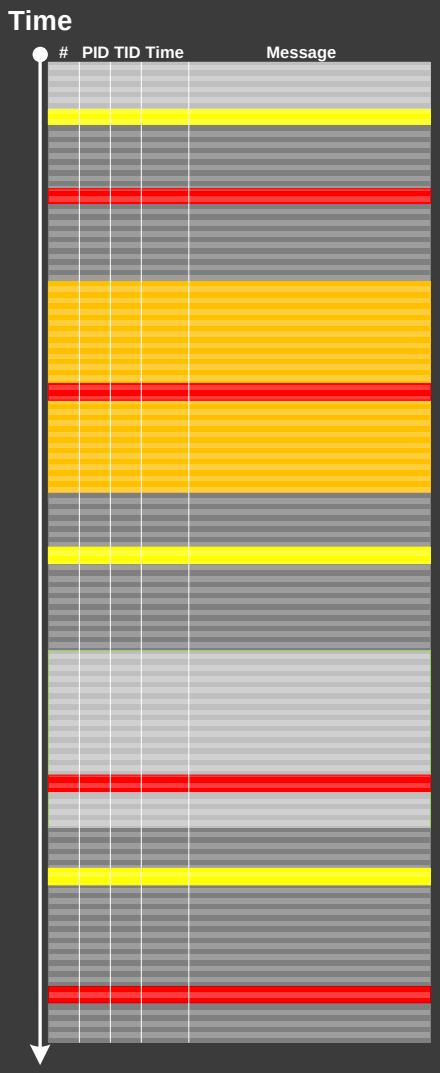
- Characteristic Message Block
- Background Components
- Foreground Components
- Layered Periodization
- Focus of Tracing
- Event Sequence Order ↓
- Trace Frames

Bird’s Eye Binary View

Characteristic Message Block



Background Components

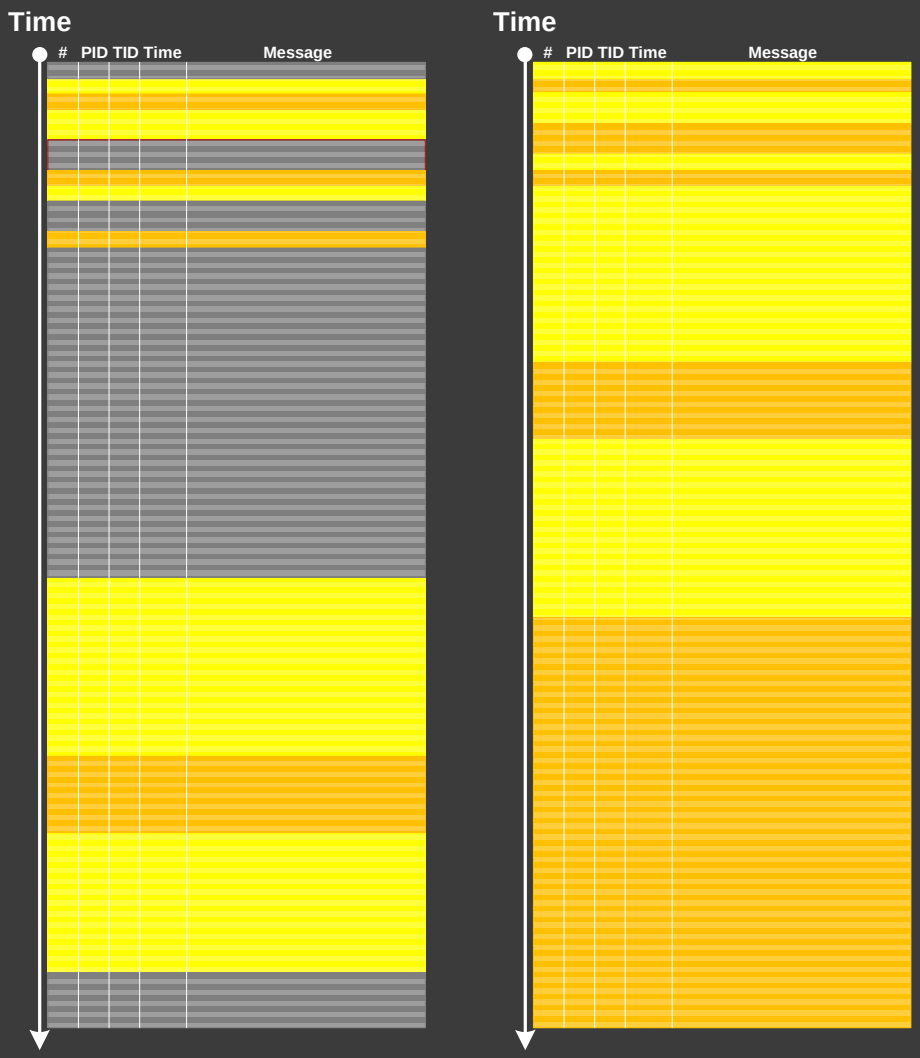


Background:

Foreground:

Related Patterns
Foreground Components

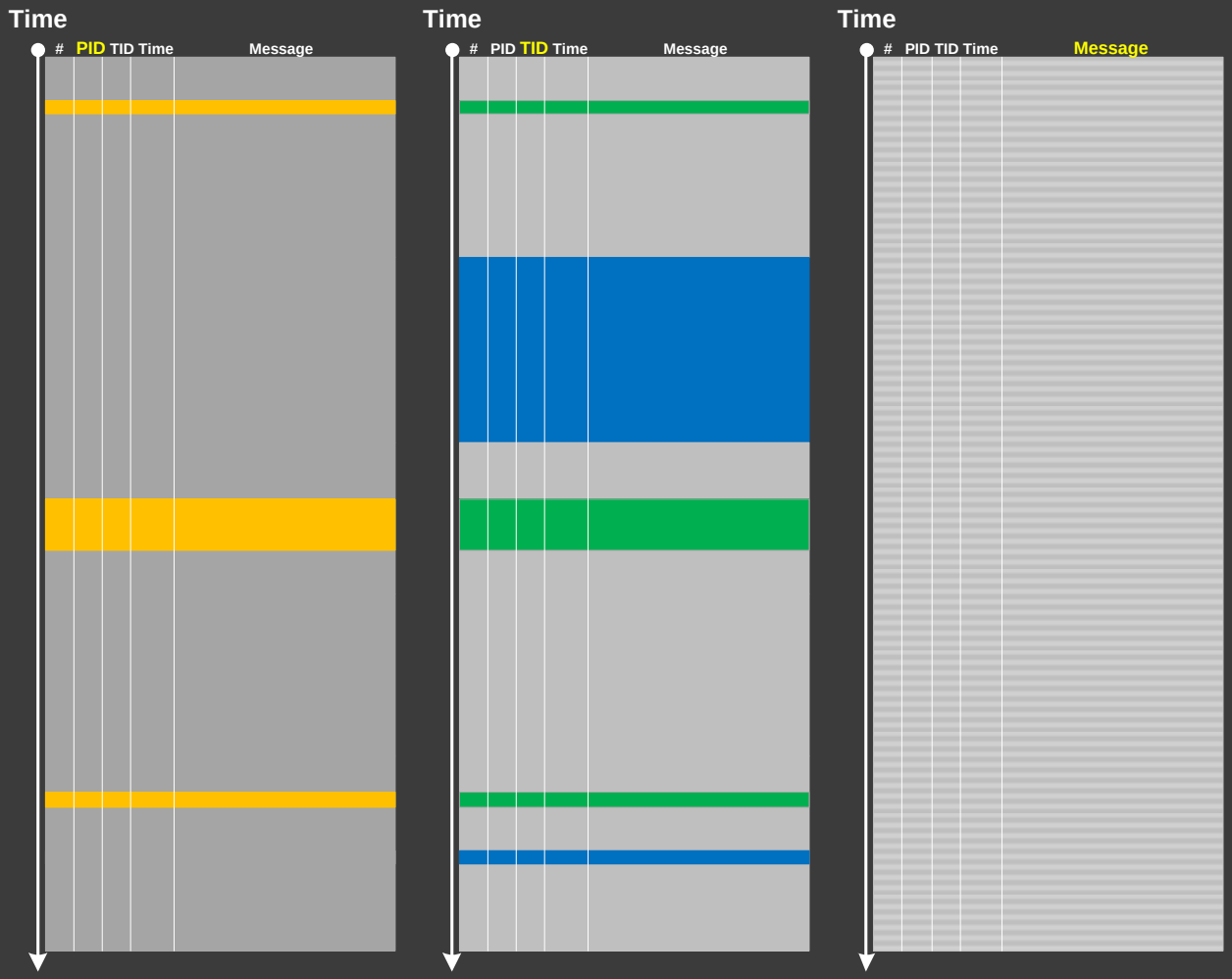
Foreground Components



Related Patterns
Background Components

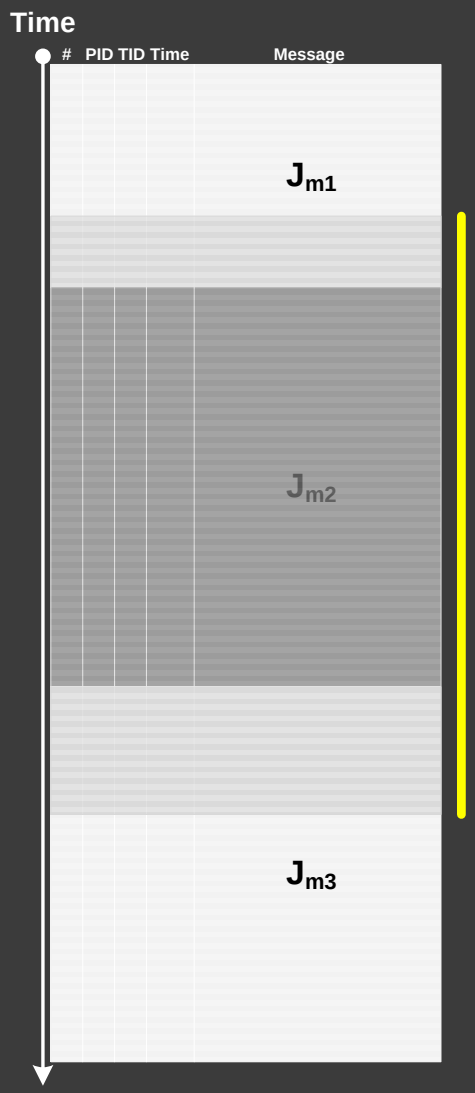
Component Foregrounding

Layered Periodization



Focus of Tracing

Related Patterns
Activity Region



Activity regions: J_{m1}, J_{m2}, J_{m3}

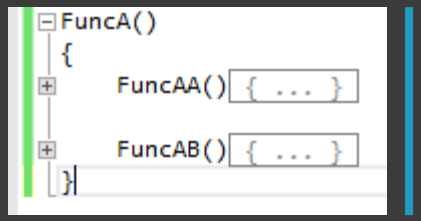
Event Sequence Order ↓

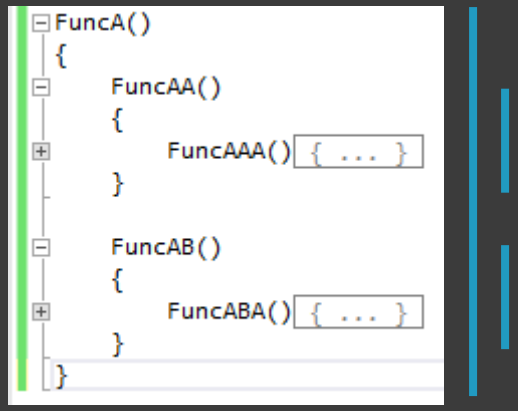
Related Patterns

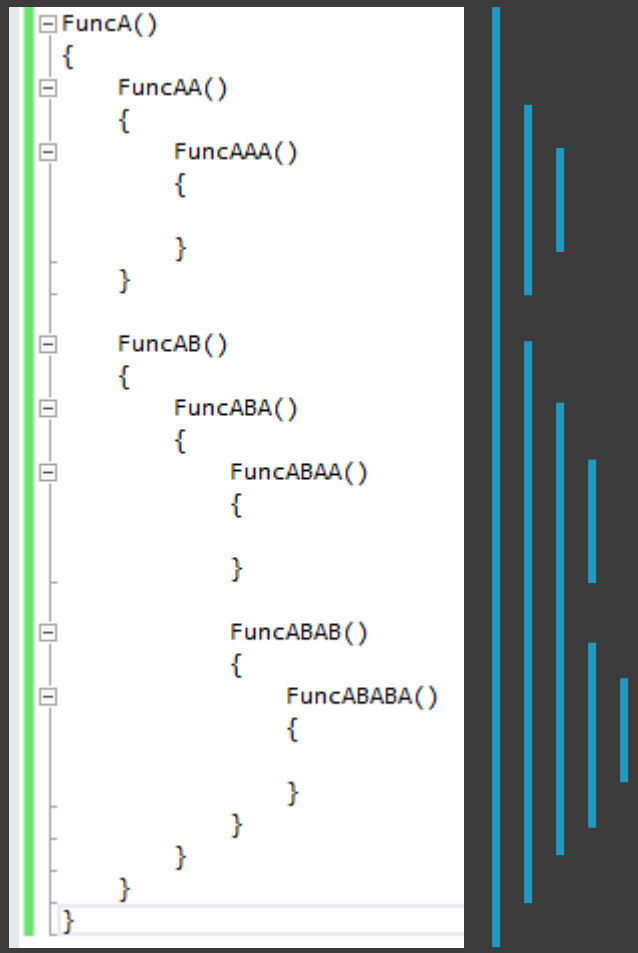
Significant Event
Anchor Messages

Synchronization
Race Conditions
Deadlock

Frames (Source Code)

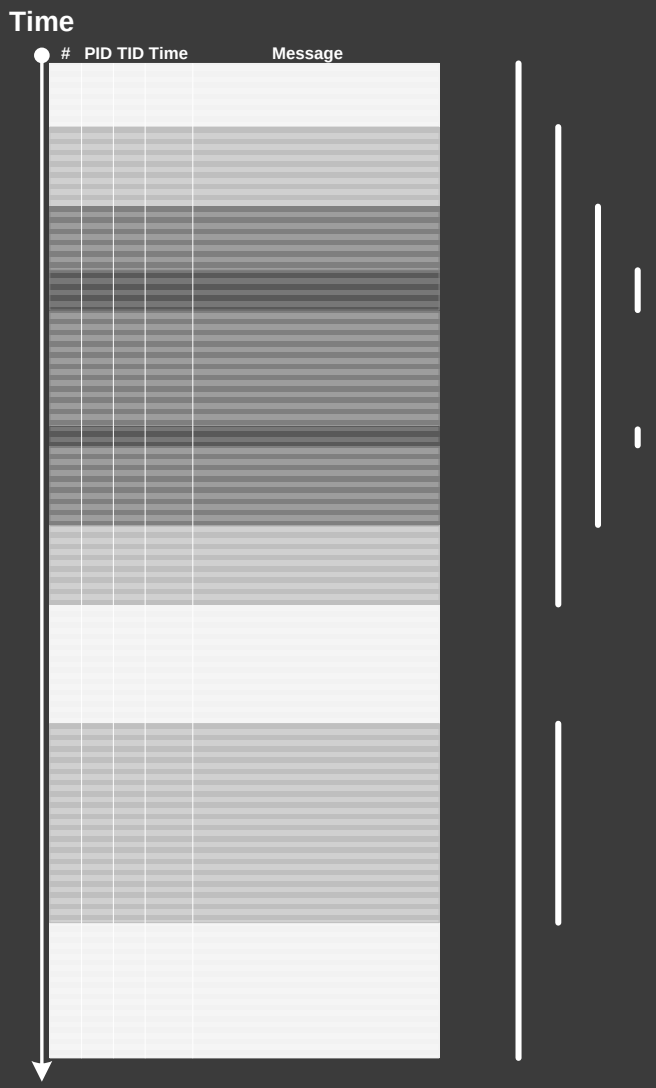






Visual Studio

Trace Frames



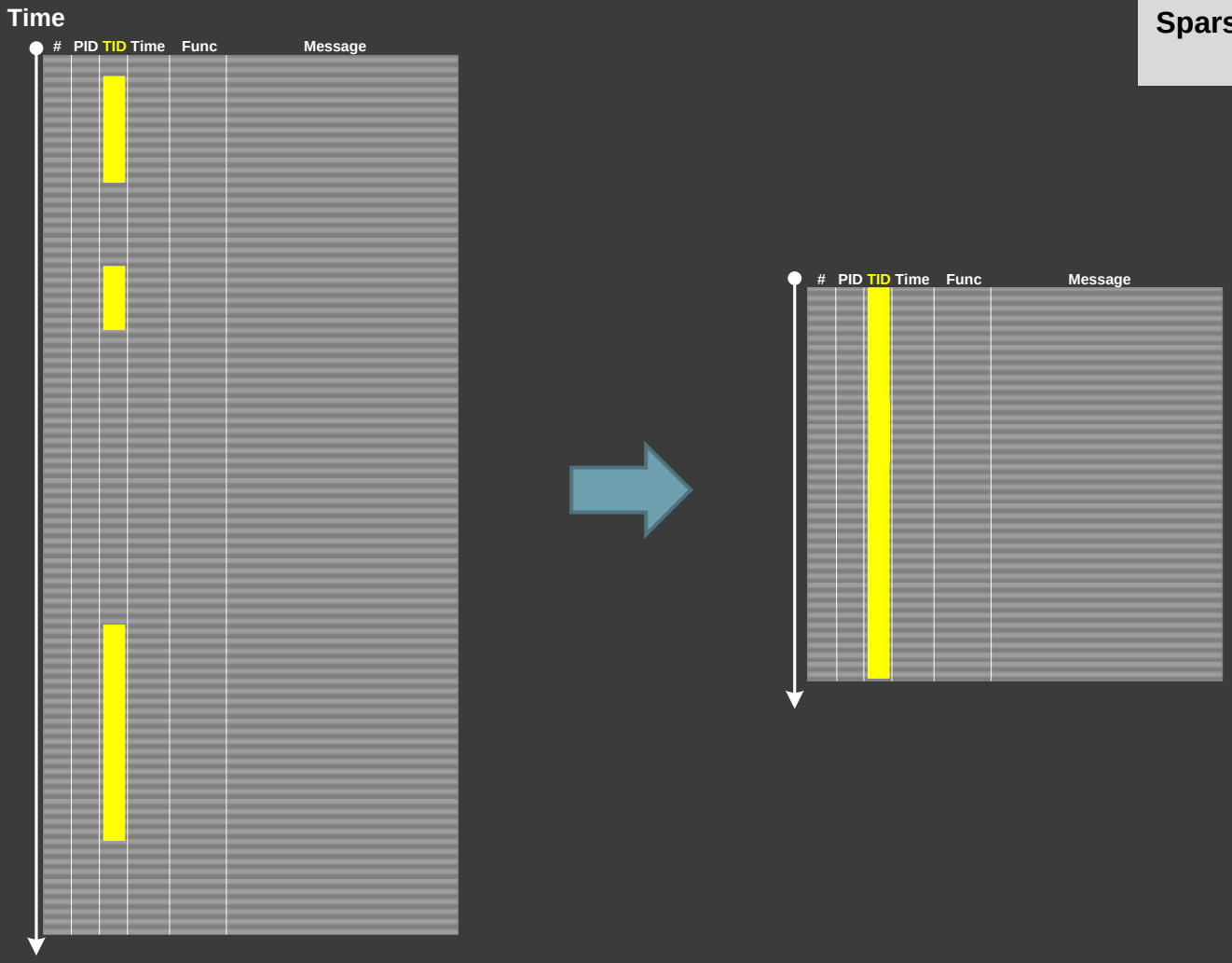
Related Patterns

Thread of Activity
Adjoint Thread
Truncated Trace
Discontinuity

Activity Patterns

- Thread of Activity ↓
- Adjoint Thread of Activity ↓
- No Activity
- Activity Region
- Discontinuity ↓
- Time Delta ↓
- Glued Activity
- Break-in Activity ↓
- Resume Activity ↓
- Data Flow ↓

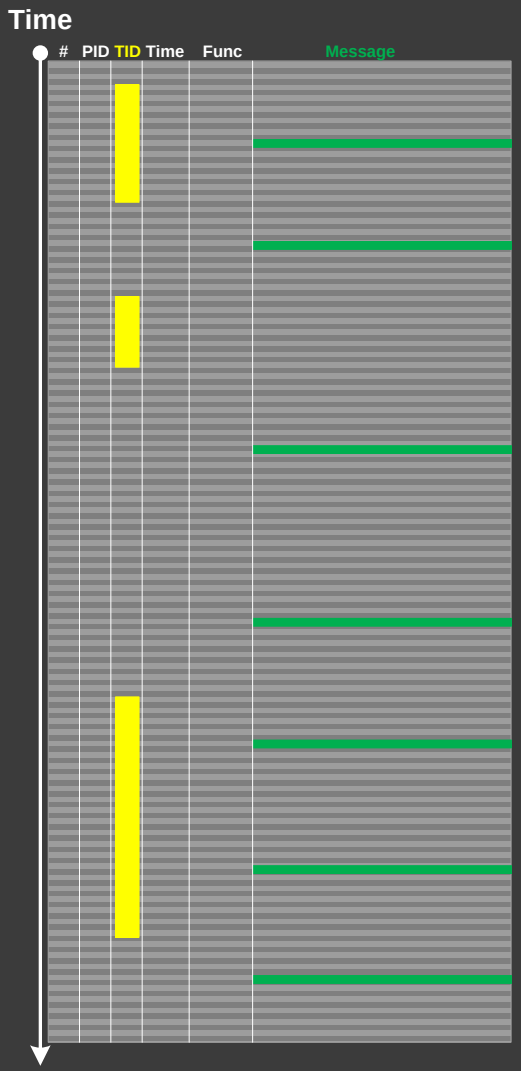
Thread of Activity ↓

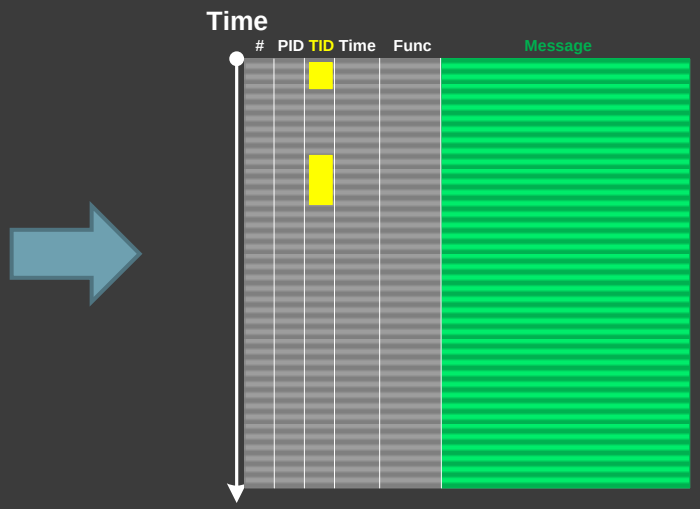


Related Patterns

Discontinuity
Sparse Trace

Adjoint Thread of Activity ↓

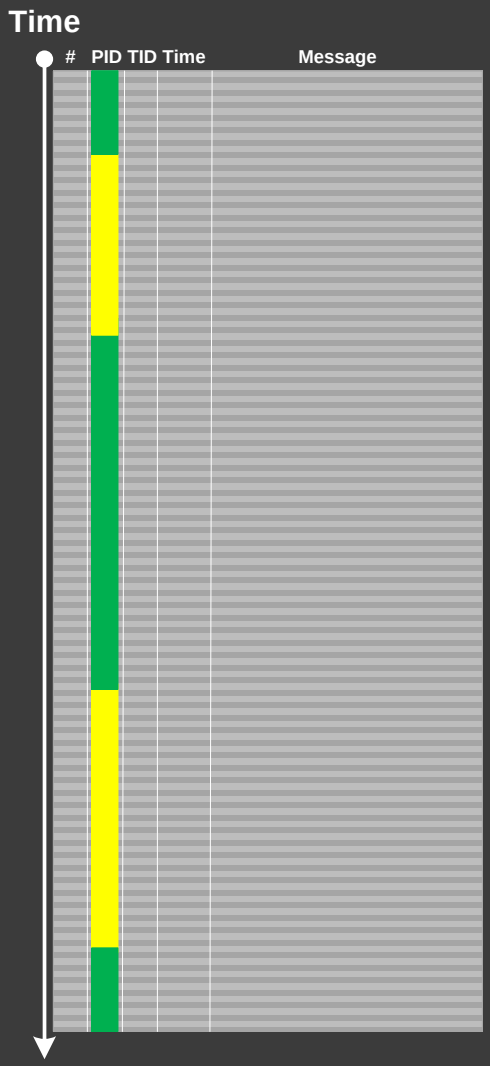




Related Patterns

Thread of Activity
Message Invariant

No Activity



We expect this process

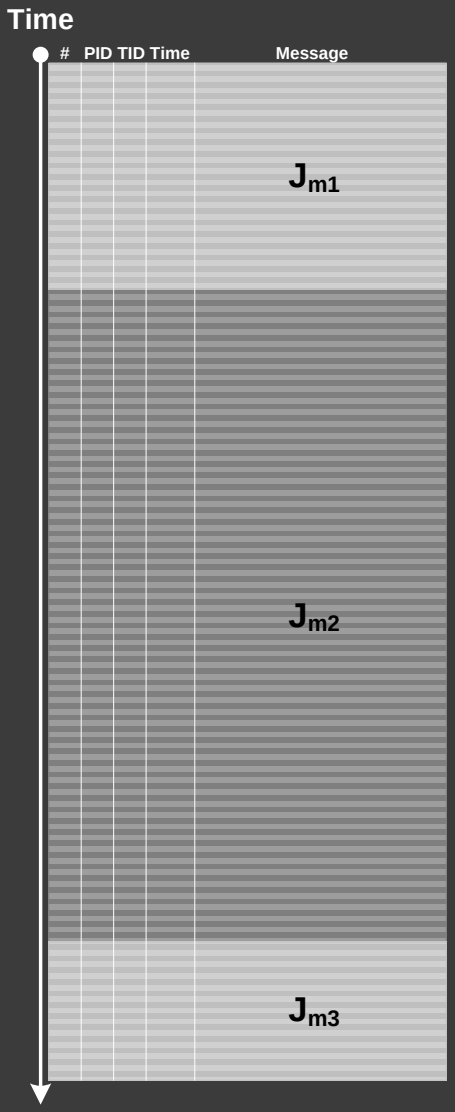
Possible causes:

hang, wait chain, deadlock, terminated threads, CPU loop

Related Patterns

Discontinuity
Sparse Trace
Missing Component

Activity Region

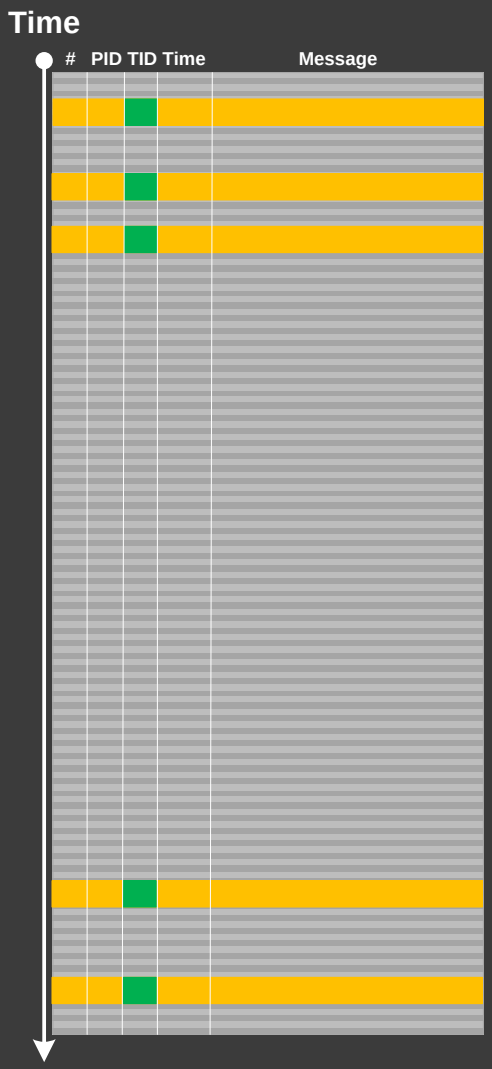


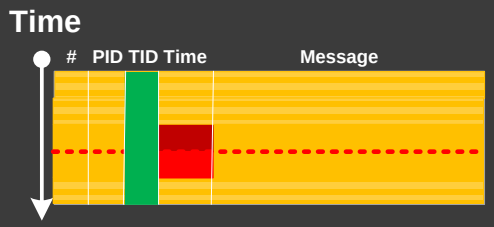
Message current : $J_{m2} > \max(J_{m1}, J_{m3})$

Related Patterns

Message Current
Characteristic Message Block

Discontinuity ↓





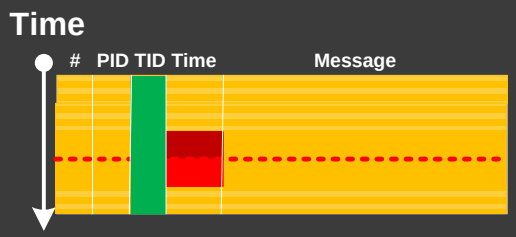
Related Patterns

Thread of Activity
Missing Component
Sparse Trace

Possible causes:

blocked thread, IPC response delay, wait chains, long computation

Time Delta ↓



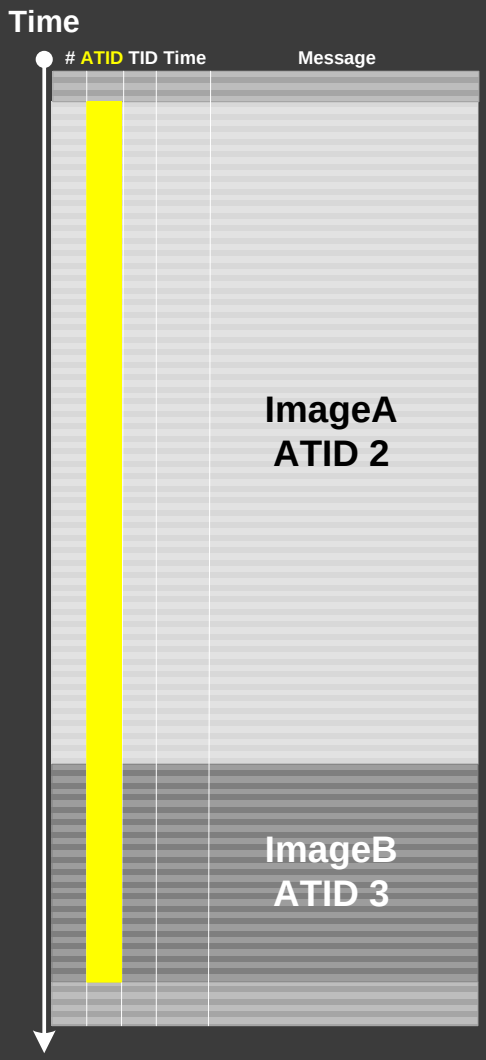
Related Patterns

Basic Facts
Thread of Activity
Discontinuity
Significant Event

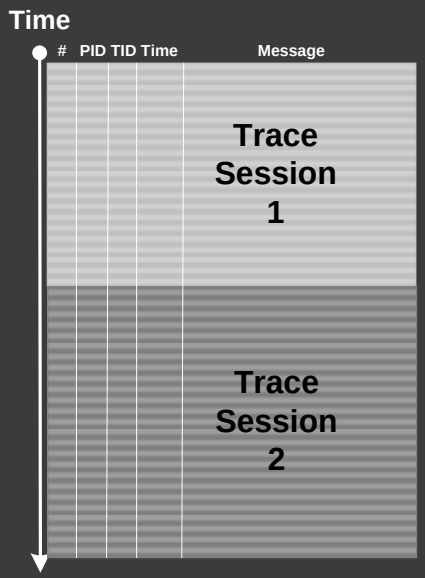
```
#     Module PID  TID  Time         File    Function  Message
-------------------------------------------------------------------------------------------
6060  dllA   1604 7108 10:06:21.746 fileA.c DllMain   DLL_PROCESS_ATTACH
24480 dllA   1604 7108 10:06:32.262 fileA.c LaunchApp Exec Path: C:\Program Files\CompanyA\appB.exe

30 seconds of discontinuity till the end of full trace
```

Glued Activity

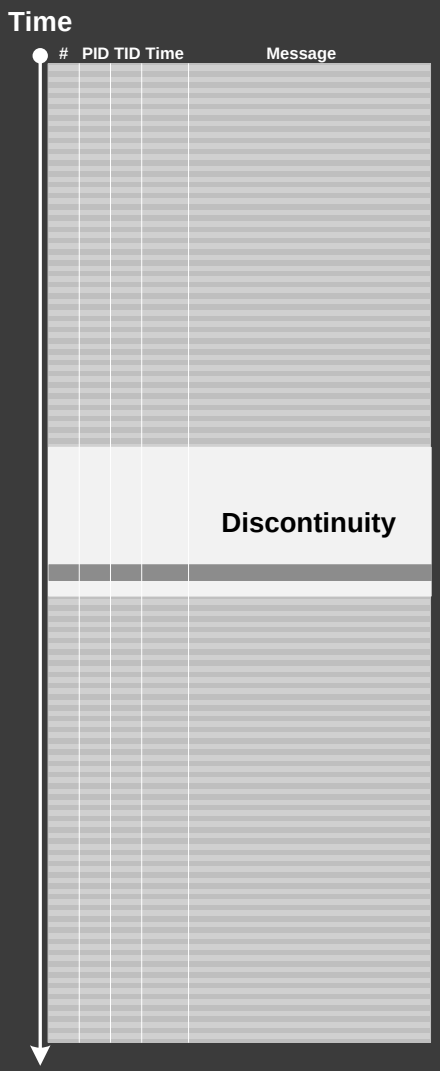
Related Patterns
Adjoint Thread



ATID: Adjoint Thread ID



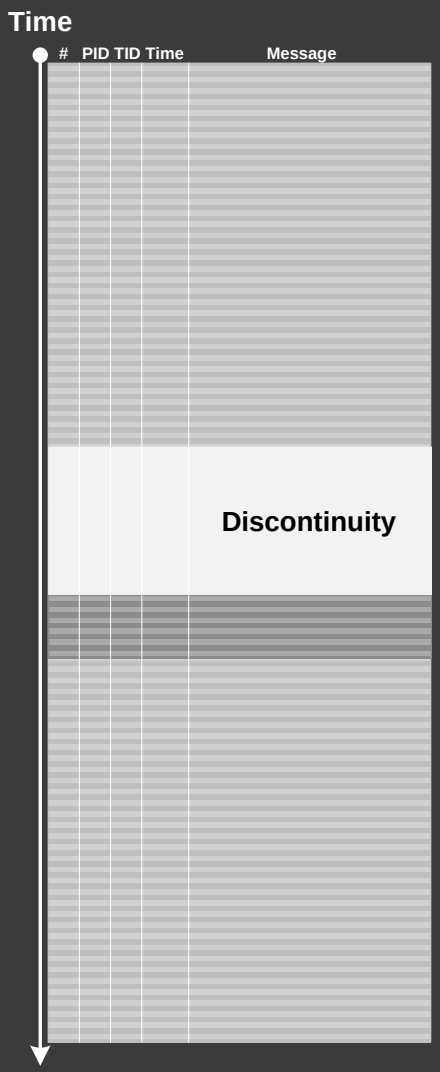
Break-in Activity ↓



Related Patterns

Thread of Activity
Adjoint Thread
Discontinuity
Resume Activity

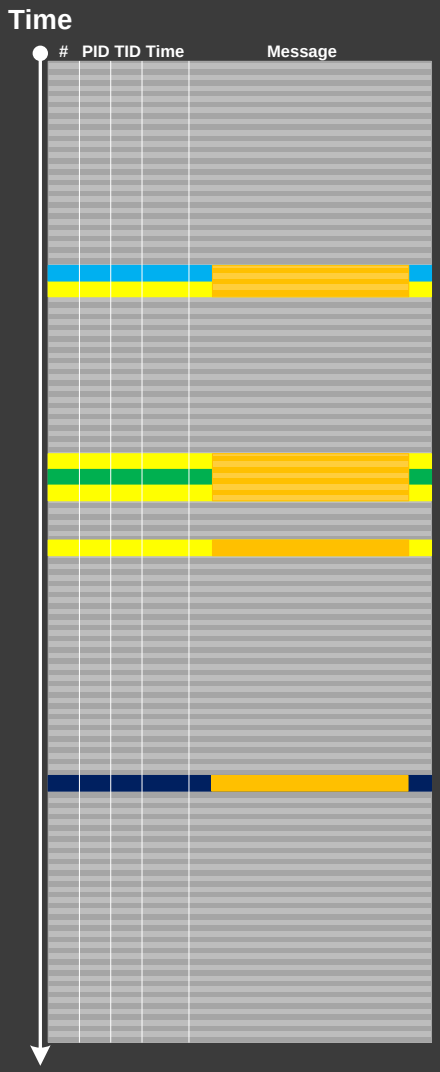
Resume Activity ↓



Related Patterns

Break-in Activity
Thread of Activity
Adjoint Thread

Data Flow ↓




```
[…]
DriverA: Device 0xA IRP 0xB
[…]
DriverB: Device 0xC IRP 0xB
[…]
DriverC: Device 0xD IRP 0xB
DriverC: Processing IRP 0xB
[…]
```

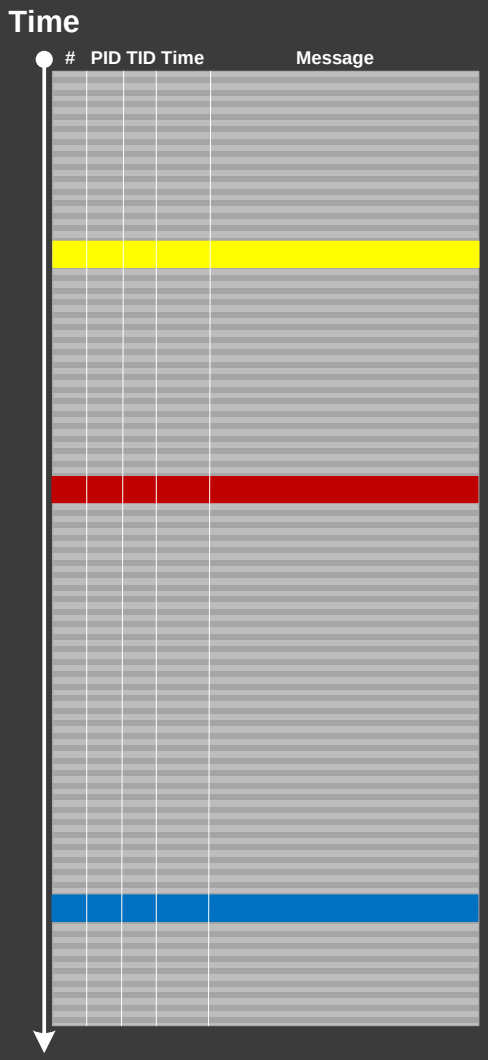
Related Patterns

Adjoint Thread
Message Invariant

Message Patterns

- Significant Event
- Defamiliarizing Effect
- Anchor Messages
- Diegetic Messages
- Message Change ↓
- Message Invariant
- UI Message
- Original Message
- Implementation Discourse
- Opposition Messages
- Linked Messages
- Gossip ↓
- Counter Value
- Message Context
- Marked Messages
- Incomplete History
- Message Interleave
- Fiber Bundle

Significant Event



Related Patterns

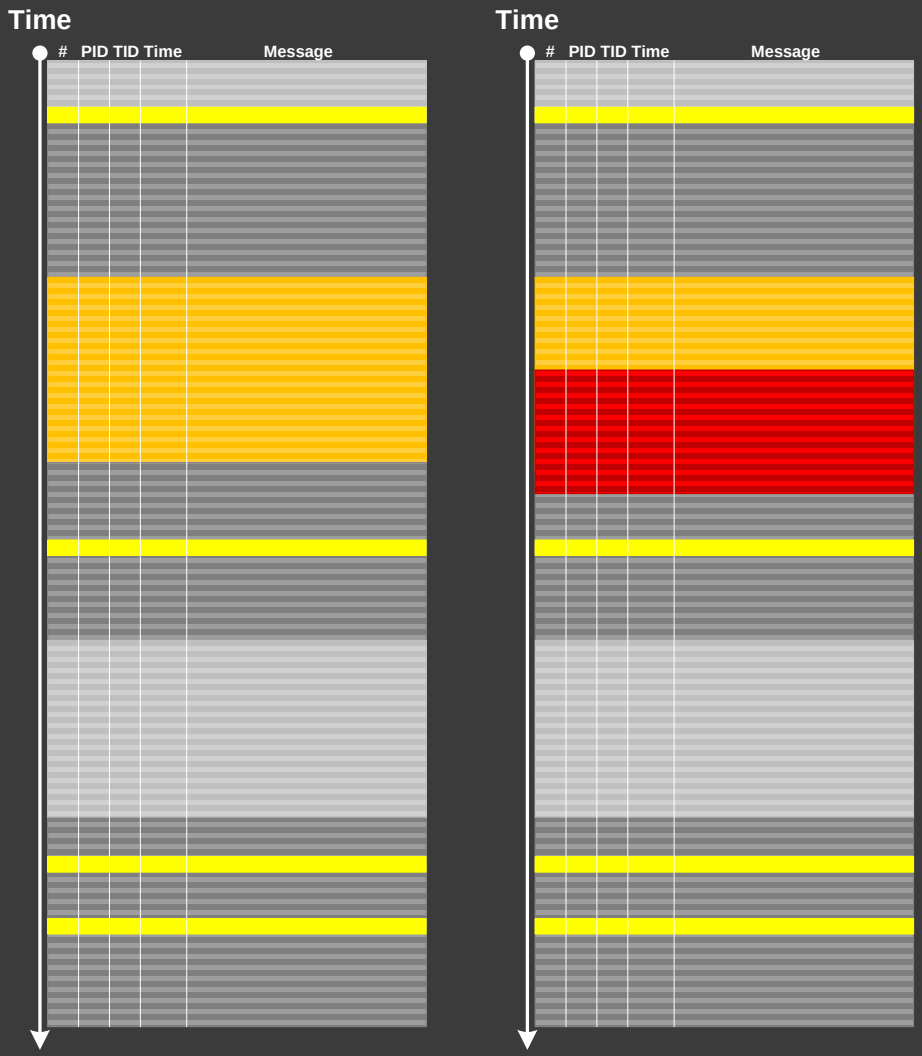
Exception Stack Trace
Error Message
Basic Facts
Vocabulary Index

Poetry of Software Traces

“Capturing delicate moments, one gives birth to a poetry of traces …”

Ange Leccia, Motionless Journeys, by Fabien Danesi

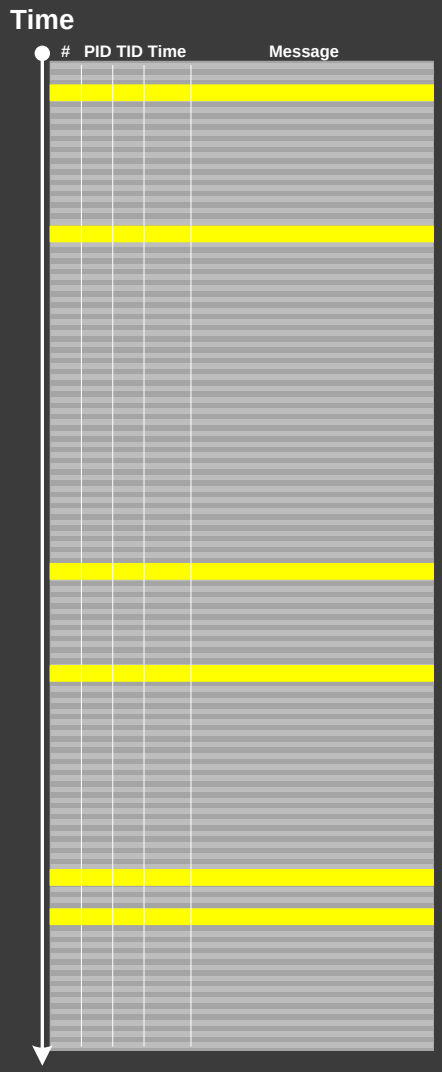
Defamiliarizing Effect



Related Patterns

Characteristic message Block
Activity Region

Anchor Messages

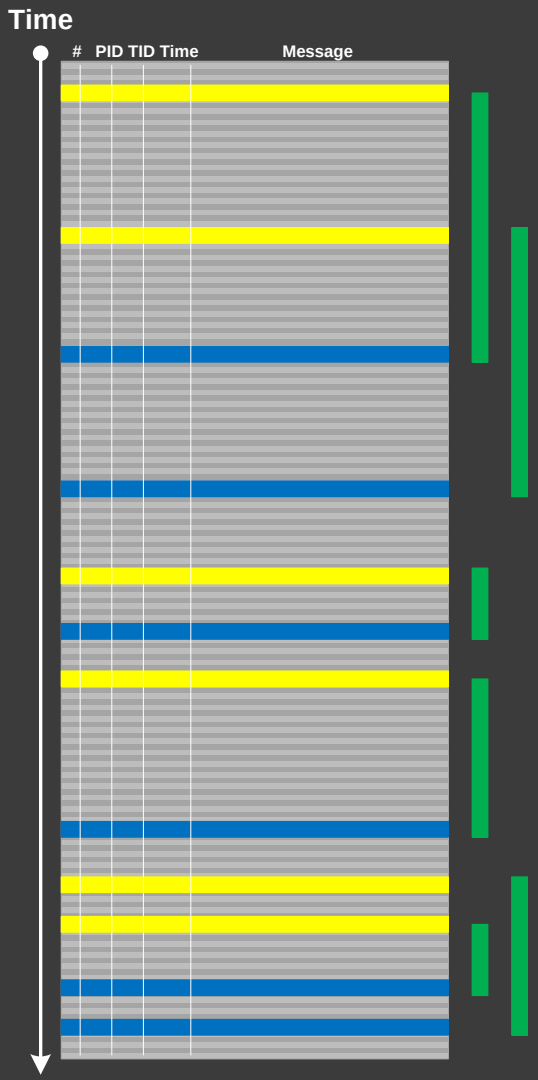


Related Patterns

Vocabulary Index
Adjoint Thread
Message Interleave

```
#      PID  TID  Time         Message
-------------------------------------------------------
24226  2656 3480 10:41:05.774 AppA.exe: DLL_PROCESS_ATTACH
108813 4288 4072 10:41:05.774 AppB.exe: DLL_PROCESS_ATTACH
112246 4180 3836 10:41:05.940 DllHost.exe: DLL_PROCESS_ATTACH
135473 2040 3296 10:41:12.615 AppC.exe: DLL_PROCESS_ATTACH
694723 1112 1992 10:44:23.393 AppD.exe: DLL_PROCESS_ATTACH
703962 5020 1080 10:44:42.014 DllHost.exe: DLL_PROCESS_ATTACH
705511 4680 3564 10:44:42.197 DllHost.exe: DLL_PROCESS_ATTACH
705891 1528 2592 10:44:42.307 regedit.exe: DLL_PROCESS_ATTACH
785231 2992 4912 10:45:26.516 AppE.exe: DLL_PROCESS_ATTACH
786523 3984 1156 10:45:26.605 powershell.exe: DLL_PROCESS_ATTACH
817979 4188 4336 10:45:48.707 wermgr.exe: DLL_PROCESS_ATTACH
834875 3976 1512 10:45:52.342 LogonUI.exe: DLL_PROCESS_ATTACH
835229 4116 3540 10:45:52.420 AppG.exe: DLL_PROCESS_ATTACH
```

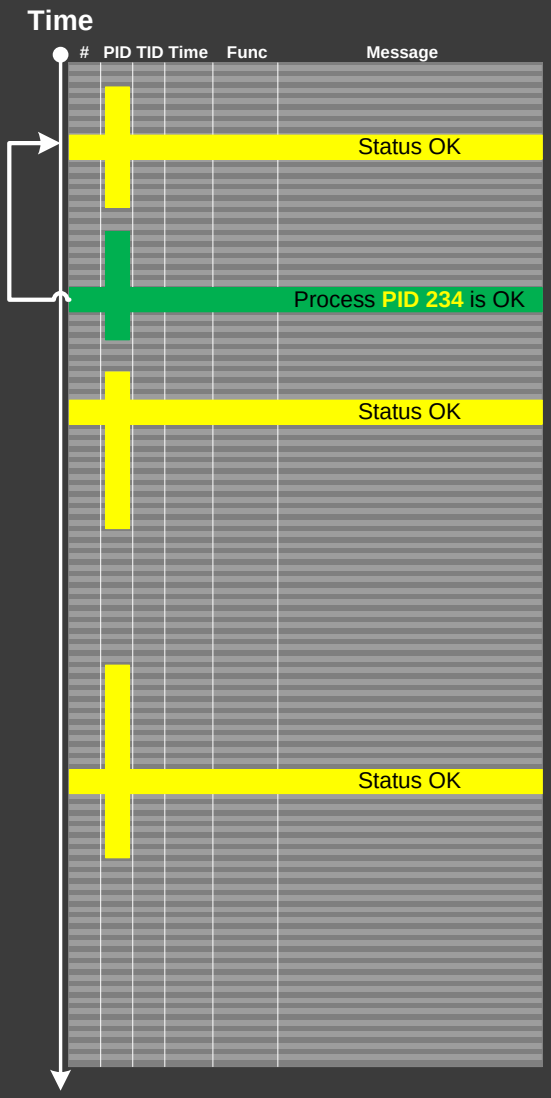
Message Interleave



Related Patterns

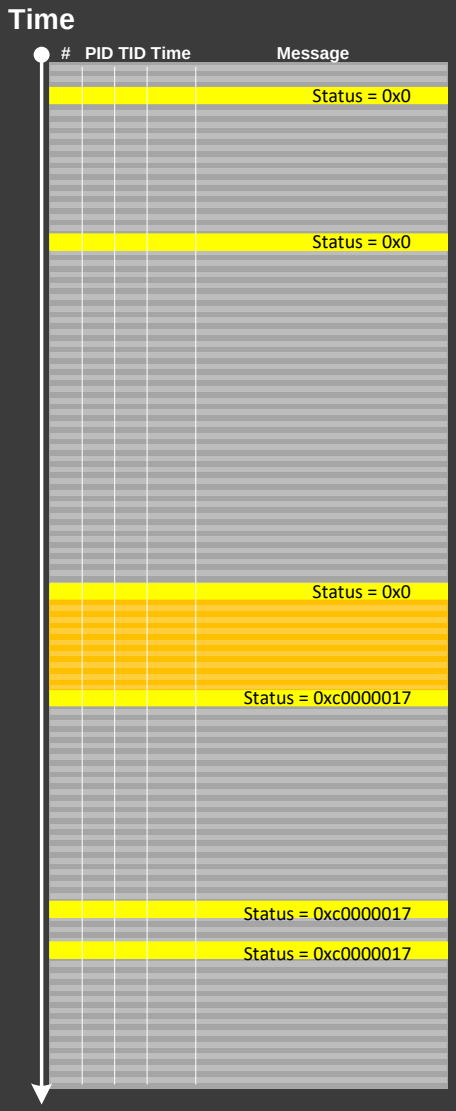
Adjoint Thread
Anchor Messages

Diegetic Messages



Related Patterns
Anchor Messages

Message Change ↓



Related Patterns

Anchor Messages
Message Invariant
Adjoint Thread

Implementation Discourse

- Win32 API
- MFC
- Kernel Development
- COM
- C# / .NET
- C++
- Java
- Python
- …

Message Invariant

Related Patterns
Trace Set

```
#    Module  PID  TID  Time         Message
-------------------------------------------------------------------------------------
[…]
2782 ModuleA 2124 5648 10:58:03.356 CreateObject: pObject 0×00A83D30 data ([…]) version 0×4
[…]
```

```
#    Module  PID  TID  Time         Message
-------------------------------------------------------------------------------------
[…]
4793 ModuleA 2376 8480 09:22:01.947 CreateObject: pObject 0×00BA4E20 data ([…]) version 0×5
[…]
```

UI Message

Related Patterns

Activity Region
Significant Event
Thread of Activity
Adjoint Thread

```
#    Module  PID  TID  Time         Message
-------------------------------------------------------------------------------
[…]
2782 ModuleA 2124 5648 10:58:03.356 CreateWindow: Title "..." Class "..."
[…]
3512 ModuleA 2124 5648 10:58:08.154 Menu command: Save Data
[…]
3583 ModuleA 2124 5648 10:58:08.155 CreateWindow: Title "Save As" Class "Dialog"
[... Data update and replication related messages ...]
4483 ModuleA 2124 5648 10:58:12.342 DestroyWindow: Title "Save As" Class "Dialog"
[…]

#    Module  PID  TID  Time         Message
-------------------------------------------------------------------------------
[…]
2782 ModuleA 2124 5648 10:58:03.356 CreateWindow: Title "..." Class "..."
3512 ModuleA 2124 5648 10:58:08.154 Menu command: Save Data
3583 ModuleA 2124 5648 10:58:08.155 CreateWindow: Title "Save As" Class "Dialog"
4483 ModuleA 2124 5648 10:58:12.342 DestroyWindow: Title "Save As" Class "Dialog"
[…]
```

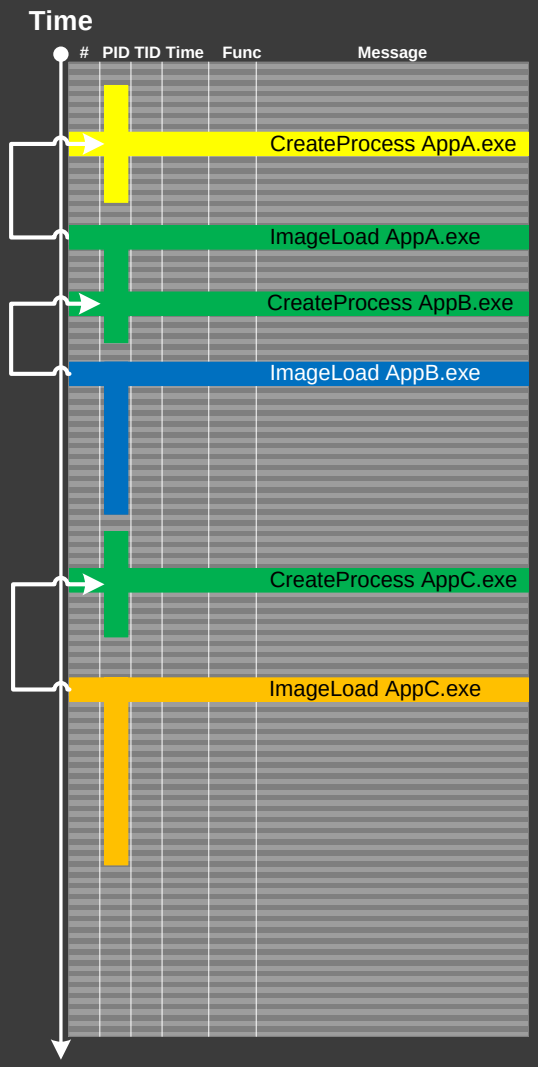
Original Message

Related Patterns

Message Invariant
Adjoint Thread

```
#     Module  PID   TID   Time         Message
-------------------------------------------------------------------------------------------------
[…]
35835 ModuleA 12332 11640 18:27:28.720 LoadLibrary: \Program Files\MyProduct\System32\MyDLL.dll PID 12332
[…]
37684 ModuleA 12332 9576  18:27:29.063 LoadLibrary: \Program Files\MyProduct\System32\MyDLL.dll PID 12332
[…]
37687 ModuleA 12332 9576  18:27:29.064 LoadLibrary: \Program Files\MyProduct\System32\MyDLL.dll PID 12332
[…]
```

Linked Messages




```
#      PID  Message
-----------------------------------------
[…]
128762 1260 CreateProcess: PPID 1260 PID 6356
[…]
128785 6356 ImageLoad: AppA.exe PID 6356
[…]
131137 6356 CreateProcess: PPID 6356 PID 6280
[…]
131239 6280 ImageLoad: AppB.exe PID 6280
[…]
132899 6356 CreateProcess: PPID 6356 PID 8144
[…]
132906 8144 ImageLoad: AppC.exe PID 8144
[…]
```

Related Patterns

Adjoint Thread

Gossip ↓

Related Patterns

Adjoint Thread
Event Sequence Order
Message Interleave

```
#     Module  PID  TID  Message
[…]
26875 ModuleA 2172 5284 LoadImage: \Device\HarddiskVolume2\Windows\System32\notepad.exe PID 0x000000000000087C
26876 ModuleB 2172 5284 LoadImage: \Device\HarddiskVolume2\Windows\System32\notepad.exe, PID (2172)
26877 ModuleC 2172 5284 ImageLoad: fileName=notepad.exe, pid: 000000000000087C
[…]
```

```
#     Module  PID  TID  Message
[…]
26875 ModuleA 2172 5284 LoadImage: \Device\HarddiskVolume2\Windows\System32\notepad.exe PID 0×000000000000087C
[…]
33132 ModuleA 4180 2130 LoadImage: \Device\HarddiskVolume2\Windows\System32\calc.exe PID 0×0000000000001054
[…]
```

Counter Value

Related Patterns

Adjoint Thread
Significant Event
Activity Region
Focus of Tracing
Characteristic Message Block

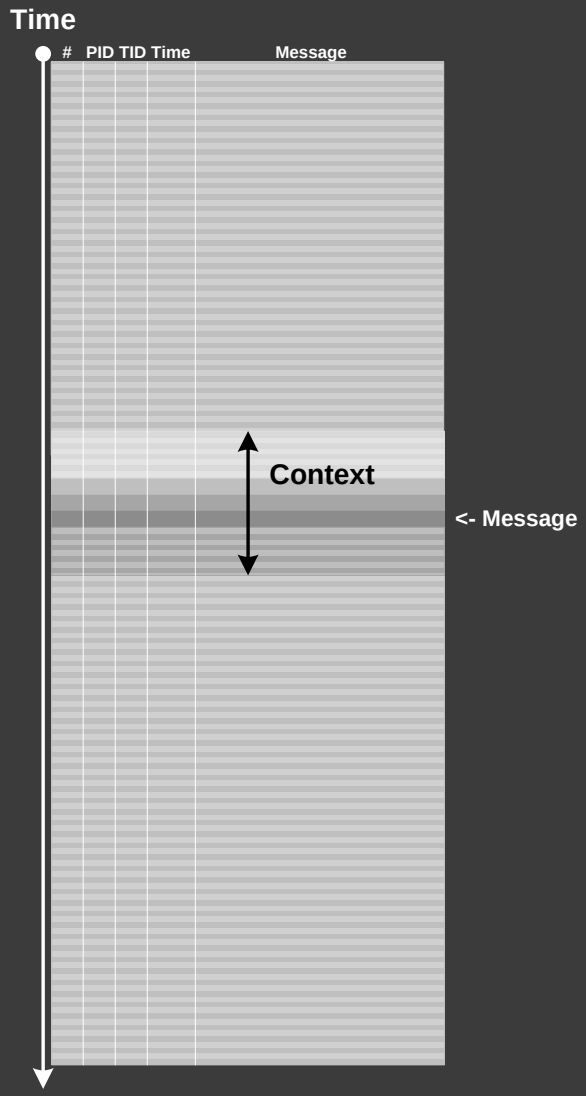
Module Variable

```
18:04:06 Explorer.EXE 3280 User Time: 8.4864544 seconds, Kernel Time: 9.5004609 seconds, Private Bytes: 42,311,680, Working Set: 10,530,816
```

Performance-specific patterns:

Global Monotonicity
Constant Value

Message Context



Related Patterns

Significant Event
Anchor Message

Marked Messages

Related Patterns
Master Trace **No Activity**

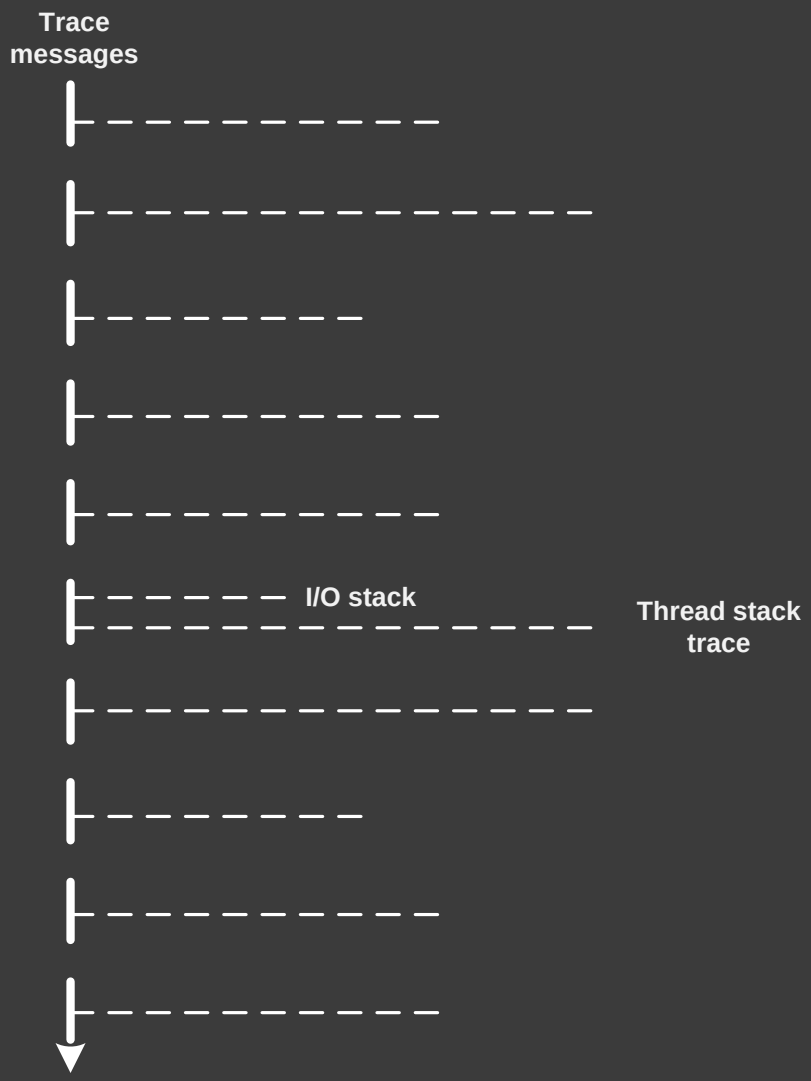
Annotated messages:

```
session database queries [+]
session initialization [-]
socket activity [+]
process A launched [+]
process B launched [-]
process A exited [-]
```

`[+]` activity is present in a trace

`[-]` activity is undetected or not present

Fiber Bundle



Related Patterns
Exception Stack Trace

Incomplete History

Code:

- Response-complete
- Exception-complete
- Call-complete

Related Patterns
Opposition Messages **Sparse Trace** **Truncated Trace** **Master Trace**

Opposition Messages

- open - close
- create – destroy (discard)
- allocate - free (deallocate)
- call - return
- enter - exit (leave)
- load - unload
- save - load
- lock - unlock
- map - unmap

Related Patterns
Incomplete History **Sparse Trace**

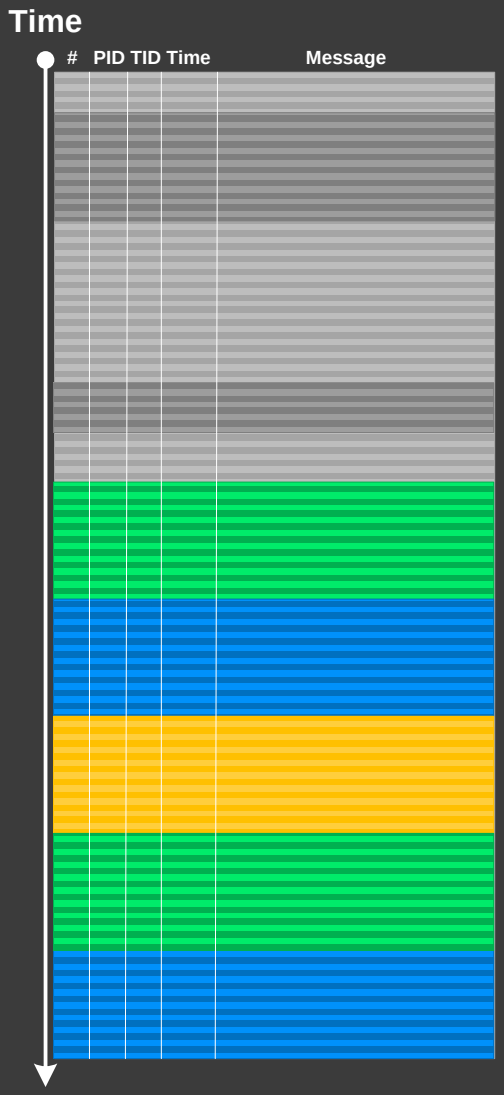
Block Patterns

- Macrofunction
- Periodic Message Block
- Intra-Correlation

Macrofunction

```
#     Module   PID  TID   Time         Message
-------------------------------------------------------------
[…]
42582 DBClient 5492 9476  11:04:33.398 Opening connection
[…]
42585 DBClient 5492 9476  11:04:33.398 Sending SQL command
[…]
42589 DBServer 6480 10288 11:04:33.399 Executing SQL command
[…]
42592 DBClient 5492 9476  11:04:33.400 Closing connection
[…]
```

Periodic Message Block



Related Patterns

Periodic Error
Adjoint Thread
Invariant Message
Discontinuity

Intra-Correlation

Related Patterns

Basic Facts
Activity Regions

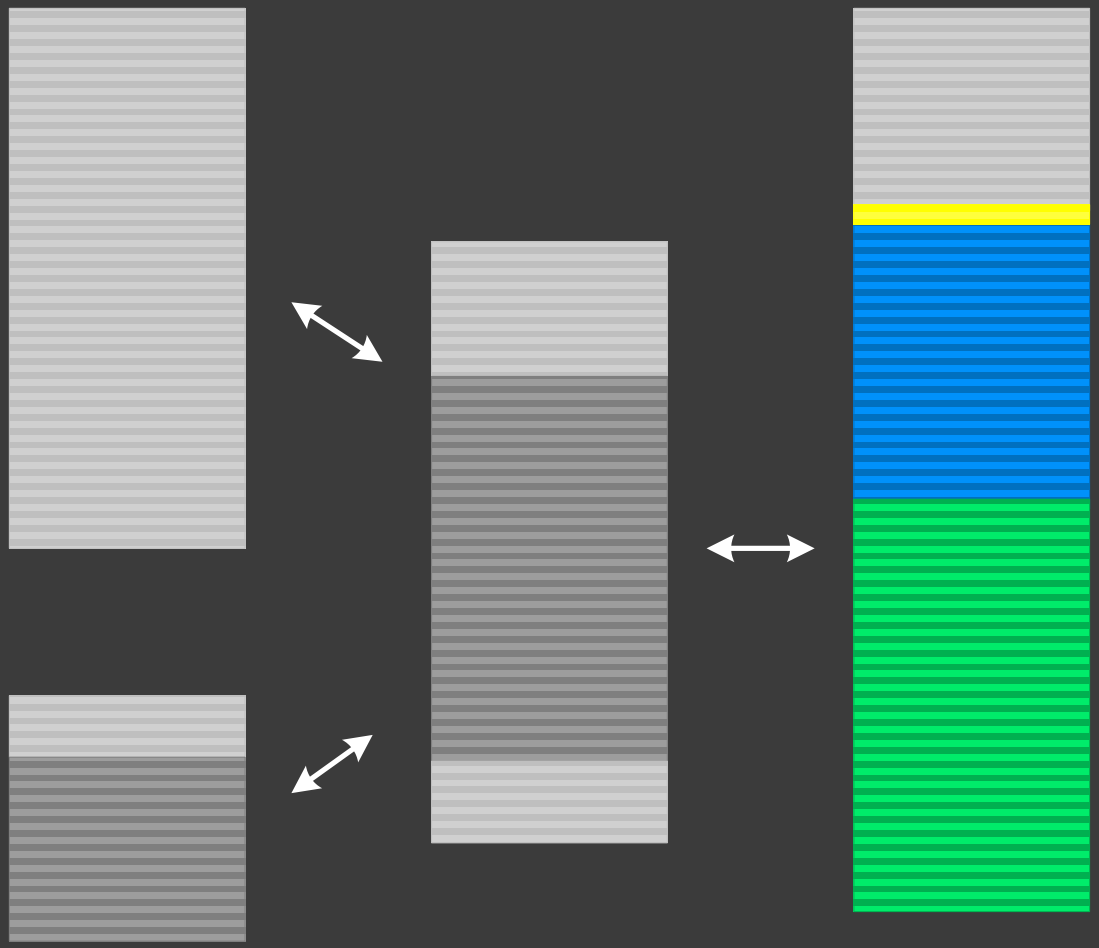
```
Handle: 00050586 Class: "Application A Class" Title: ""
Title changed at 15:52:4:3 to "Application A"
Title changed at 15:52:10:212 to "Application A - File1"
[…]
Process ID: 89c
Thread ID: d6c
[…]
Visible: true
Window placement command: SW_SHOWNORMAL
Placement changed at 15:54:57:506 to SW_SHOWMINIMIZED
Placement changed at 15:55:2:139 to SW_SHOWNORMAL
Foreground: false
Foreground changed at 15:52:4:3 to true
Foreground changed at 15:53:4:625 to false
Foreground changed at 15:53:42:564 to true
Foreground changed at 15:53:44:498 to false
Foreground changed at 15:53:44:498 to true
Foreground changed at 15:53:44:592 to false
Foreground changed at 15:53:45:887 to true
Foreground changed at 15:53:47:244 to false
Foreground changed at 15:53:47:244 to true
Foreground changed at 15:53:47:353 to false
Foreground changed at 15:54:26:416 to true
Foreground changed at 15:54:27:55 to false
Foreground changed at 15:54:27:55 to true
Foreground changed at 15:54:27:180 to false
[…]
```

```
Handle: 000D0540 Class: "App B" Title: "Application B"
[...]
Process ID: 3ac
Thread ID: bd4
[...]
Foreground: false
Foreground changed at 15:50:36:972 to true
Foreground changed at 15:50:53:732 to false
Foreground changed at 15:50:53:732 to true
Foreground changed at 15:50:53:826 to false
Foreground changed at 15:51:51:352 to true
Foreground changed at 15:51:53:941 to false
Foreground changed at 15:53:8:135 to true
Foreground changed at 15:53:8:182 to false
Foreground changed at 15:53:10:178 to true
Foreground changed at 15:53:13:938 to false
Foreground changed at 15:53:30:443 to true
Foreground changed at 15:53:31:20 to false
Foreground changed at 15:53:31:20 to true
Foreground changed at 15:53:31:129 to false
[…]
```

Trace Set Patterns

- Master Trace
- Bifurcation Point
- Inter-Correlation
- Relative Density
- News Value
- Impossible Trace
- Split Trace

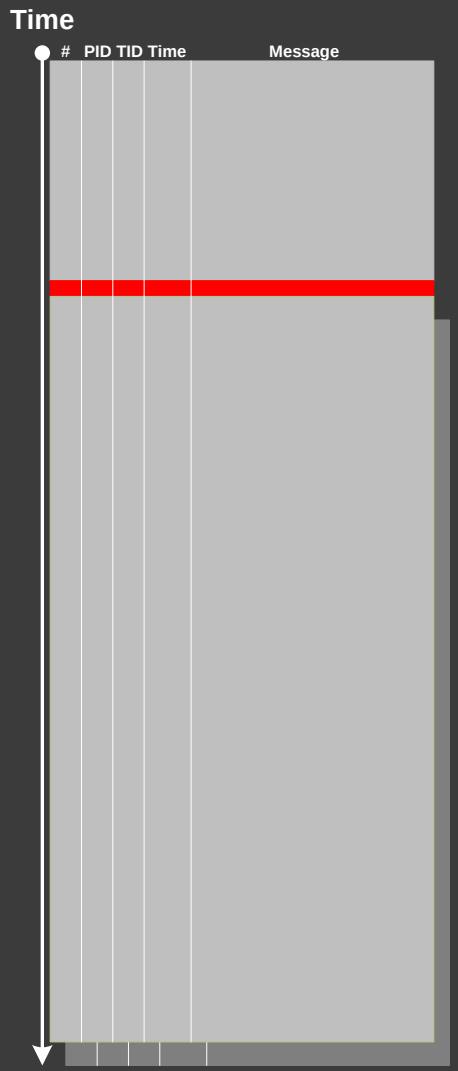
Master Trace



Related Patterns

Activity Regions
Background Components
Foreground Components
Event Sequence Order
Guest Component
Implementation Discourse
Bifurcation Point

Bifurcation Point

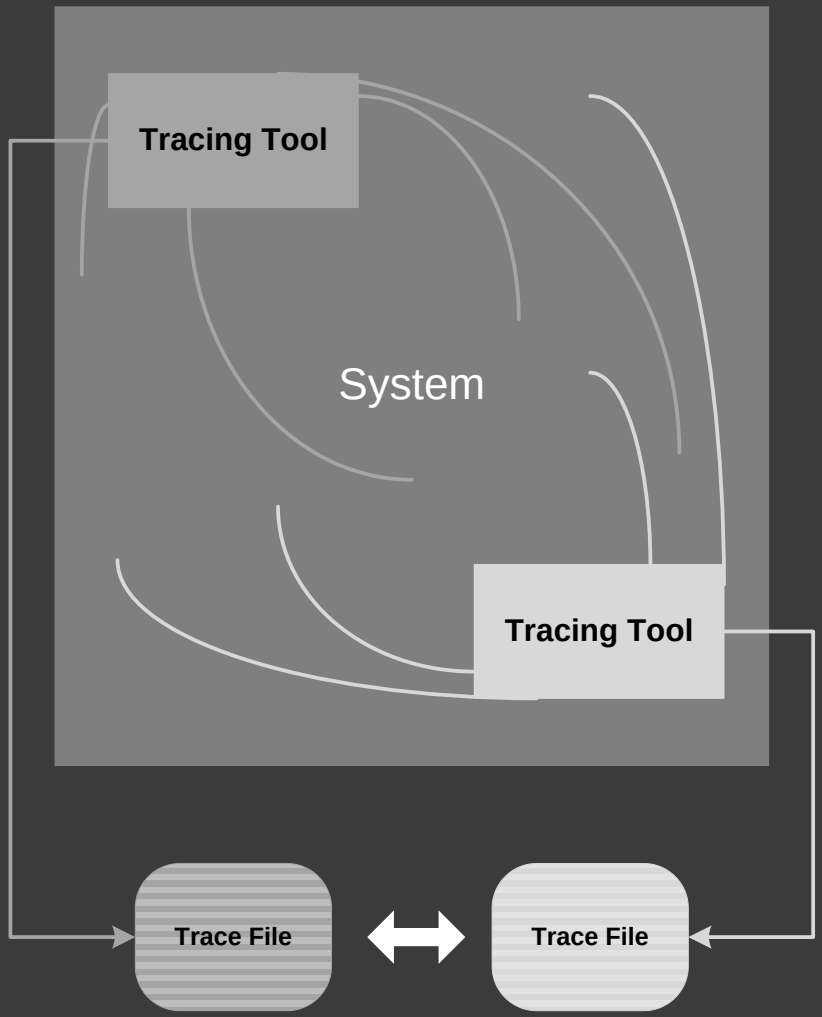


Software Trace Diagrams

```
#  PID  TID  Message
-----------------------------------
[…]
25 2768 3056 Trace Statement A
26 3756 2600 Trace Statement B
27 3756 2600 Trace Statement C
[…]
149 3756 836 Query result: X
150 3756 836 Trace Statement 150.1
151 3756 836 Trace Statement 151.1
152 3756 836 Trace Statement 152.1
153 3756 836 Trace Statement 153.1
[…]
```

```
#  PID  TID  Message
-----------------------------------
[…]
27 2768 3056 Trace Statement A
28 3756 2176 Trace Statement B
29 3756 2176 Trace Statement C
[…]
151 3756 5940 Query result: Y
152 3756 5940 Trace Statement 152.2
153 3756 5940 Trace Statement 153.2
154 3756 5940 Trace Statement 154.2
155 3756 5940 Trace Statement 155.2
[…]
```

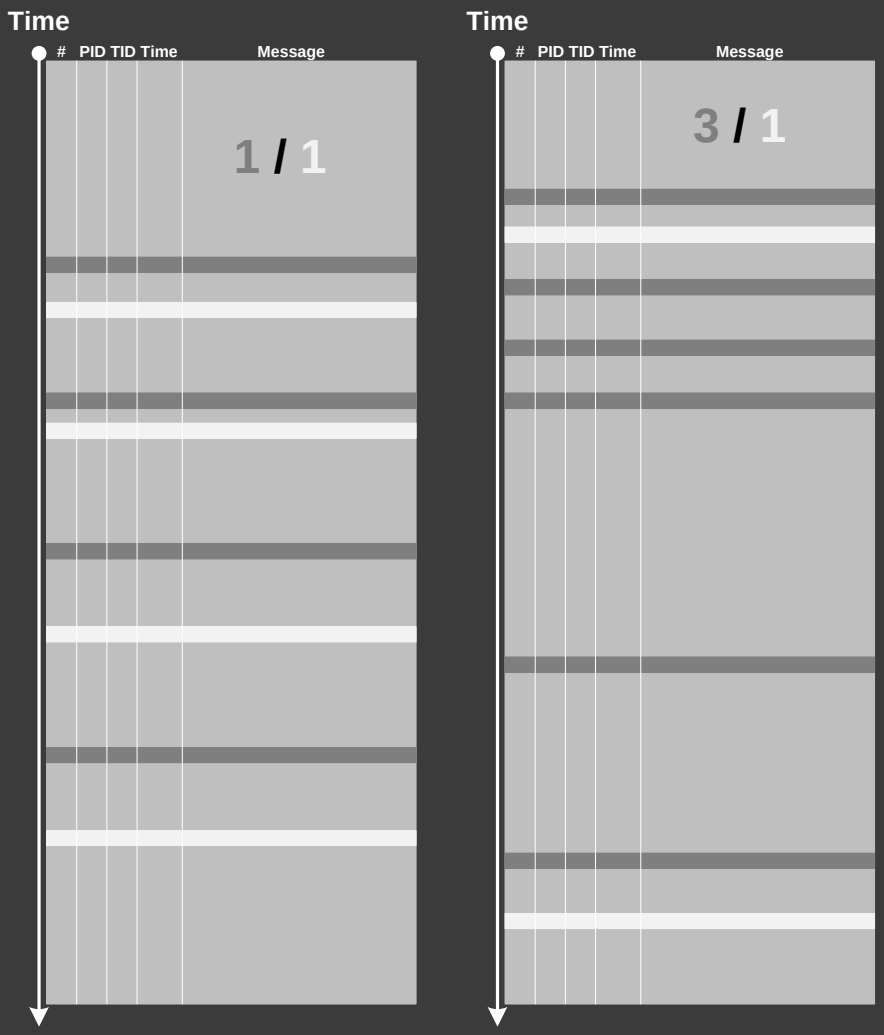
Inter-Correlation



Related Patterns

Intra-Correlation
Basic Facts
Discontinuity
Sparse Trace

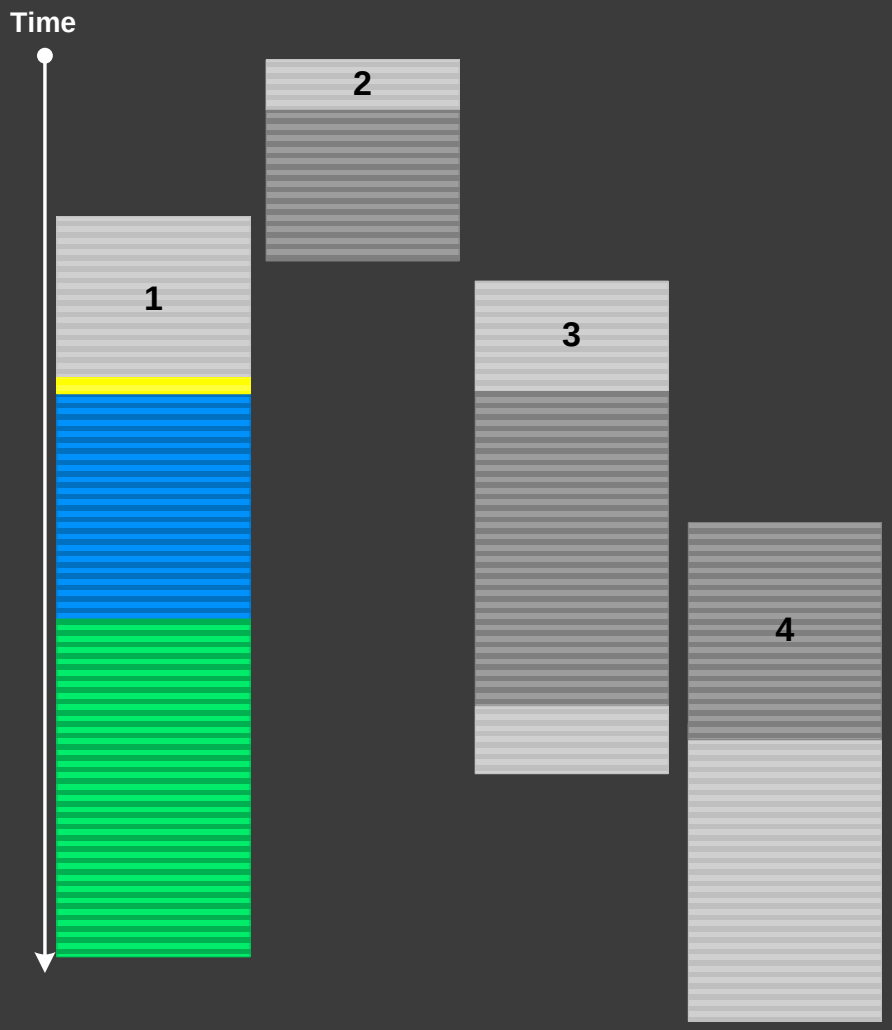
Relative Density



Related Patterns

Message Density

News Value



Related Patterns

Inter-Correlation
Basic Facts
Master Trace

Impossible Trace

Related Patterns
Sparse Trace

```
#    Module  PID TID Message
------------------------------
[…]
1001 ModuleA 202 404 foo: start
1002 ModuleA 202 404 foo: end
[…]
```

```
void foo()
{
  TRACE("foo: start");
  bar();
  TRACE("foo: end");
}

void bar()
{
  TRACE("bar: start");
  // some code ...
  TRACE("bar: end");
}
```

Split Trace

Related Patterns
Circular Trace

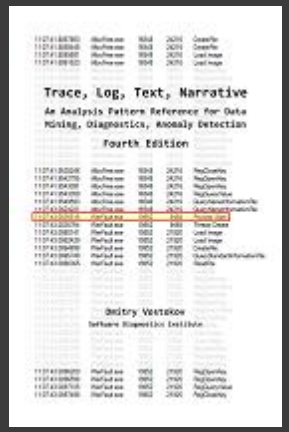
12.12.12

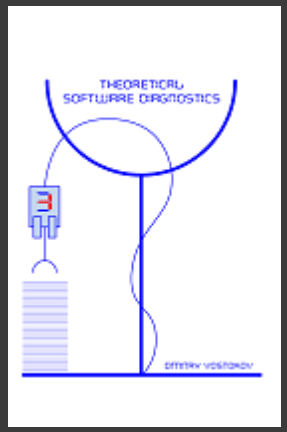
Related Patterns

Adjoint Thread
Discontinuity
Time Delta
Periodic Message Block

Resources

- TraceAnalysis.org / PatternDiagnostics.com
- Debugging.TV / YouTube.com/DebuggingTV / YouTube.com/PatternDiagnostics
- Software Trace and Memory Dump Analysis
- Software Diagnostics: Collected Seminars
- Theoretical Software Diagnostics, Third Edition
- Trace, Log, Text, Narrative: An Analysis Pattern Reference for Data Mining, Diagnostics, Anomaly Detection, Fourth Edition





Q&A

Please send your feedback using the contact form on PatternDiagnostics.com

Thank you for attendance!