



# Software Trace Analysis

## Accelerated

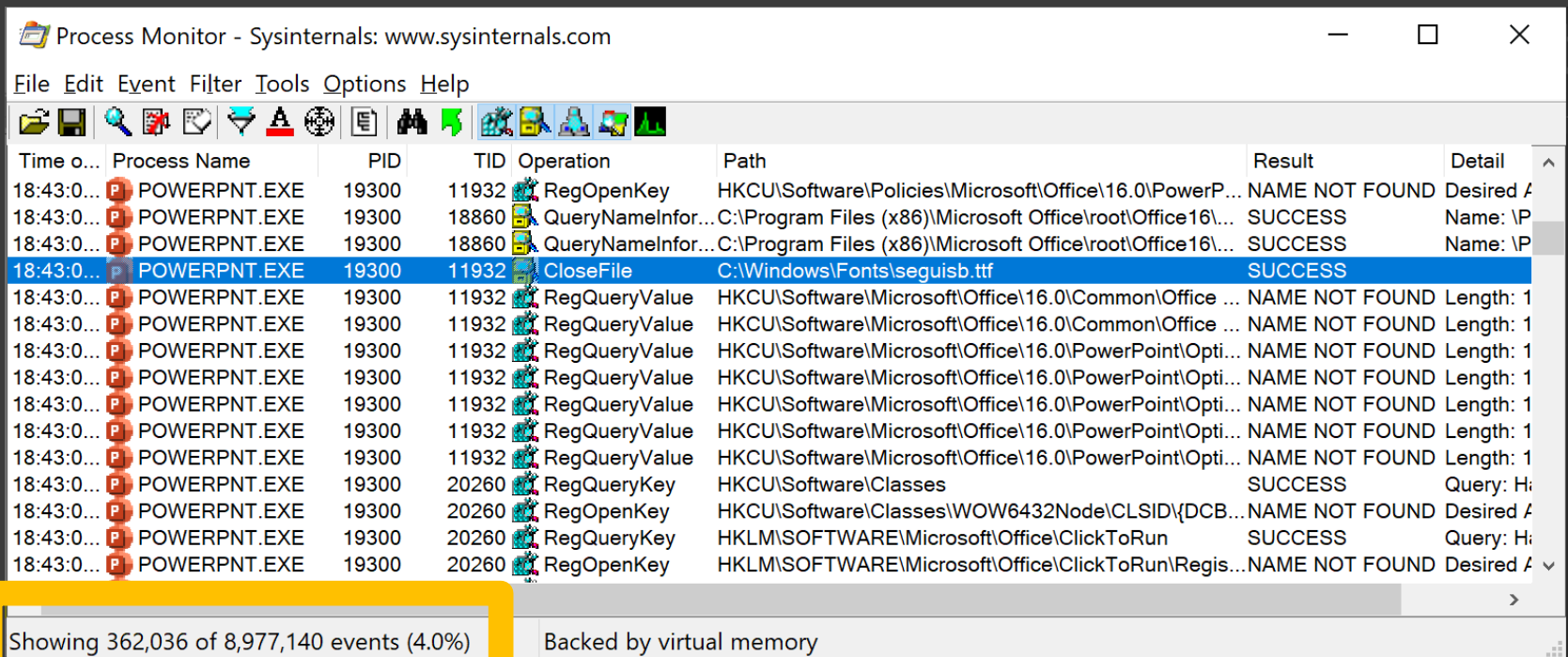
**Revised Version**

**Part 1: Fundamentals and Basic Patterns**

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Software Diagnostics Services

# What's it all About?

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



Process Monitor - Sysinternals: www.sysinternals.com

File Edit Event Filter Tools Options Help

Time o...	Process Name	PID	TID	Operation	Path	Result	Detail
18:43:0...	POWERPNT.EXE	19300	11932	RegOpenKey	HKCU\Software\Policies\Microsoft\Office\16.0\PowerP...	NAME NOT FOUND	Desired A
18:43:0...	POWERPNT.EXE	19300	18860	QueryNameInfor...	C:\Program Files (x86)\Microsoft Office\root\Office16\...	SUCCESS	Name: \P
18:43:0...	POWERPNT.EXE	19300	18860	QueryNameInfor...	C:\Program Files (x86)\Microsoft Office\root\Office16\...	SUCCESS	Name: \P
18:43:0...	POWERPNT.EXE	19300	11932	CloseFile	C:\Windows\Fonts\seguisb.ttf	SUCCESS	
18:43:0...	POWERPNT.EXE	19300	11932	RegQueryValue	HKCU\Software\Microsoft\Office\16.0\Common\Office ...	NAME NOT FOUND	Length: 1
18:43:0...	POWERPNT.EXE	19300	11932	RegQueryValue	HKCU\Software\Microsoft\Office\16.0\Common\Office ...	NAME NOT FOUND	Length: 1
18:43:0...	POWERPNT.EXE	19300	11932	RegQueryValue	HKCU\Software\Microsoft\Office\16.0\PowerPoint\Opti...	NAME NOT FOUND	Length: 1
18:43:0...	POWERPNT.EXE	19300	11932	RegQueryValue	HKCU\Software\Microsoft\Office\16.0\PowerPoint\Opti...	NAME NOT FOUND	Length: 1
18:43:0...	POWERPNT.EXE	19300	11932	RegQueryValue	HKCU\Software\Microsoft\Office\16.0\PowerPoint\Opti...	NAME NOT FOUND	Length: 1
18:43:0...	POWERPNT.EXE	19300	11932	RegQueryValue	HKCU\Software\Microsoft\Office\16.0\PowerPoint\Opti...	NAME NOT FOUND	Length: 1
18:43:0...	POWERPNT.EXE	19300	20260	RegQueryKey	HKCU\Software\Classes	SUCCESS	Query: Hi
18:43:0...	POWERPNT.EXE	19300	20260	RegOpenKey	HKCU\Software\Classes\WOW6432Node\CLSID{DCB...	NAME NOT FOUND	Desired A
18:43:0...	POWERPNT.EXE	19300	20260	RegQueryKey	HKLM\SOFTWARE\Microsoft\Office\ClickToRun	SUCCESS	Query: Hi
18:43:0...	POWERPNT.EXE	19300	20260	RegOpenKey	HKLM\SOFTWARE\Microsoft\Office\ClickToRun\Regis...	NAME NOT FOUND	Desired A

Showing 362,036 of 8,977,140 events (4.0%)      Backed by virtual memory

# 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

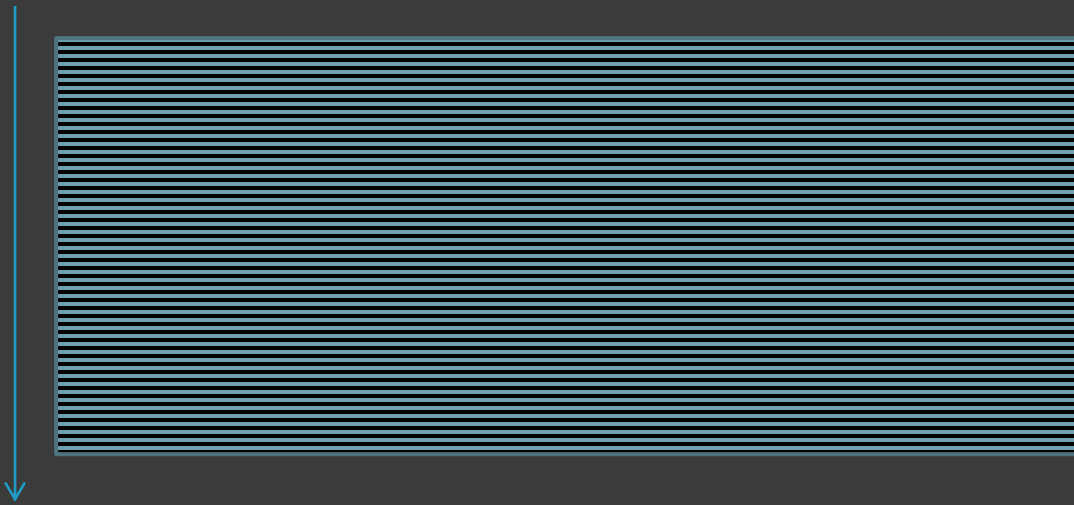
# Part 1A: Fundamentals

# 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:

svchost.exe

PID 1

PID 2

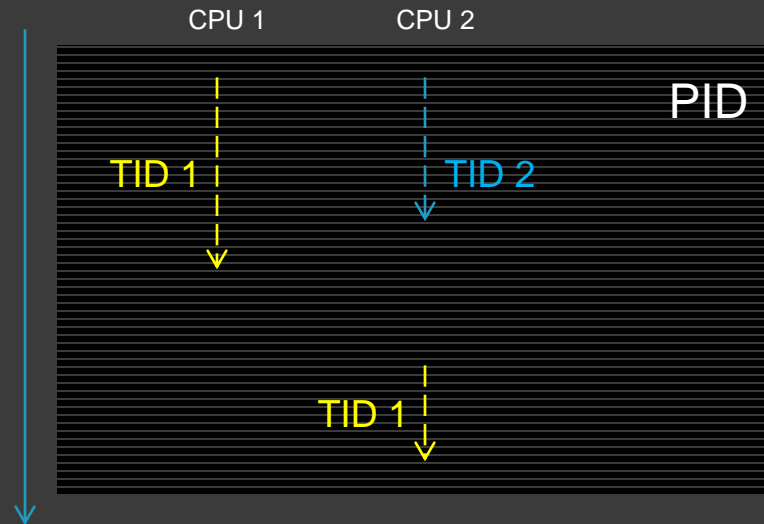
notepad.exe

PID 3

PID 4

# Thread

- TID
- CPU
- Context



# Adjoint Thread

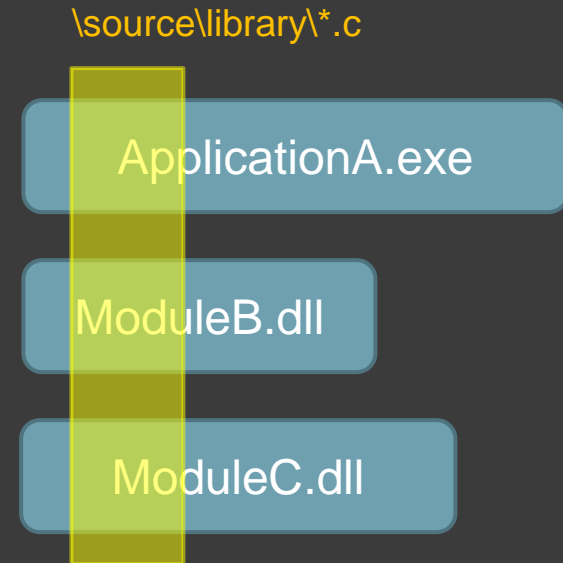
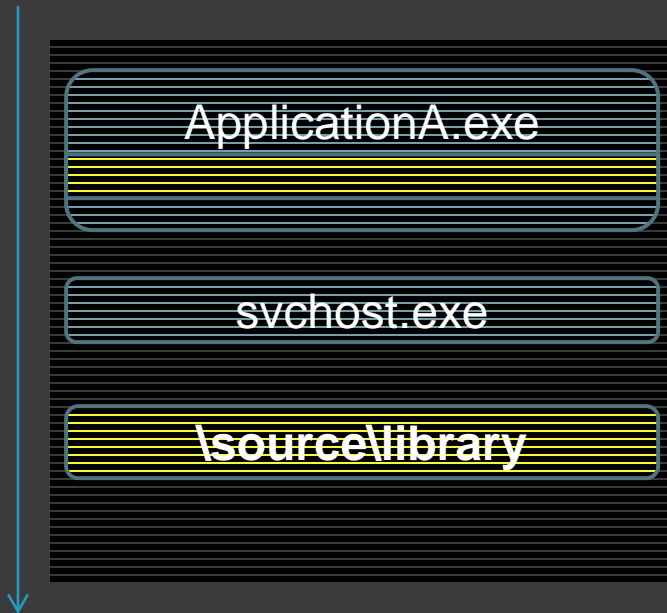
The image shows two screenshots of the Process Monitor application. The left screenshot shows a context menu open over a selected event in the main window. The menu options include: Properties... (Ctrl+P), Stack... (Ctrl+K), Toggle Bookmark (Ctrl+B), Jump To... (Ctrl+J), Search Online..., Include 'POWERPNT.EXE', Exclude 'POWERPNT.EXE', Highlight 'POWERPNT.EXE', Copy 'POWERPNT.EXE', Edit Filter 'POWERPNT.EXE', Exclude Events Before, Exclude Events After, Include, Exclude, and Highlight. A blue arrow points from the 'Include' option to the right-hand screenshot.

The right screenshot shows the same Process Monitor window, but the context menu is closed. The main window displays a list of events. The selected event is: 18:43:0... POWERPNT.E... 19300 11932 CloseFile C:\W... The status bar at the bottom indicates 'Showing 165,601 of 4,380,977 events (3.7%) Backed by virtual i...'

Debugging TV Frame 0x14

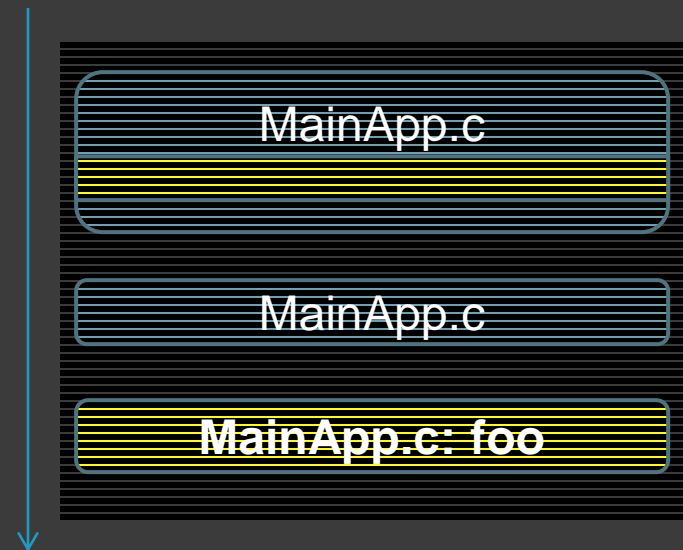
# Component / Module / Source

- 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");
}
```

Invariant

Variable

Invariant

Variable

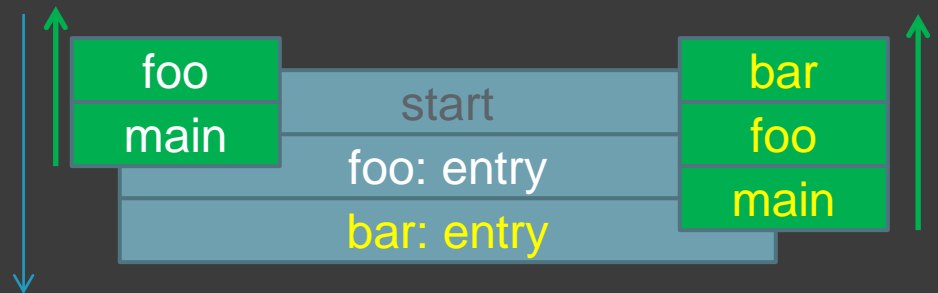
...

# Stack Trace

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

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

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



# Minimal Trace Graphs

Time



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.

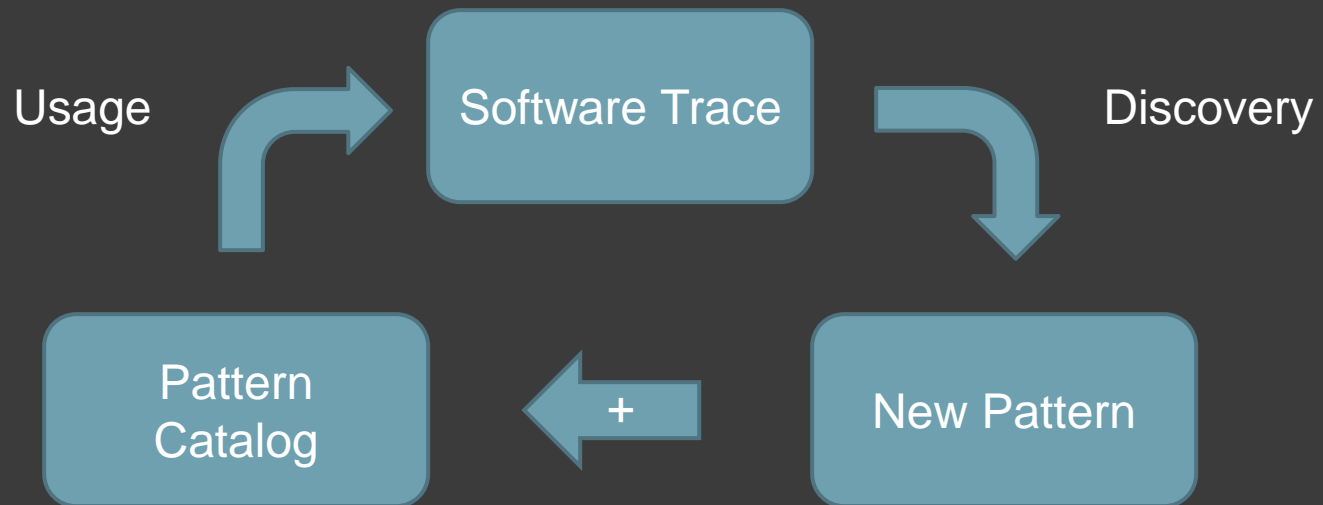
**Diagnostics Pattern Language:** common names of diagnostic and diagnostic analysis patterns. The same language for any operating system: Windows, macOS, Linux, ...



**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

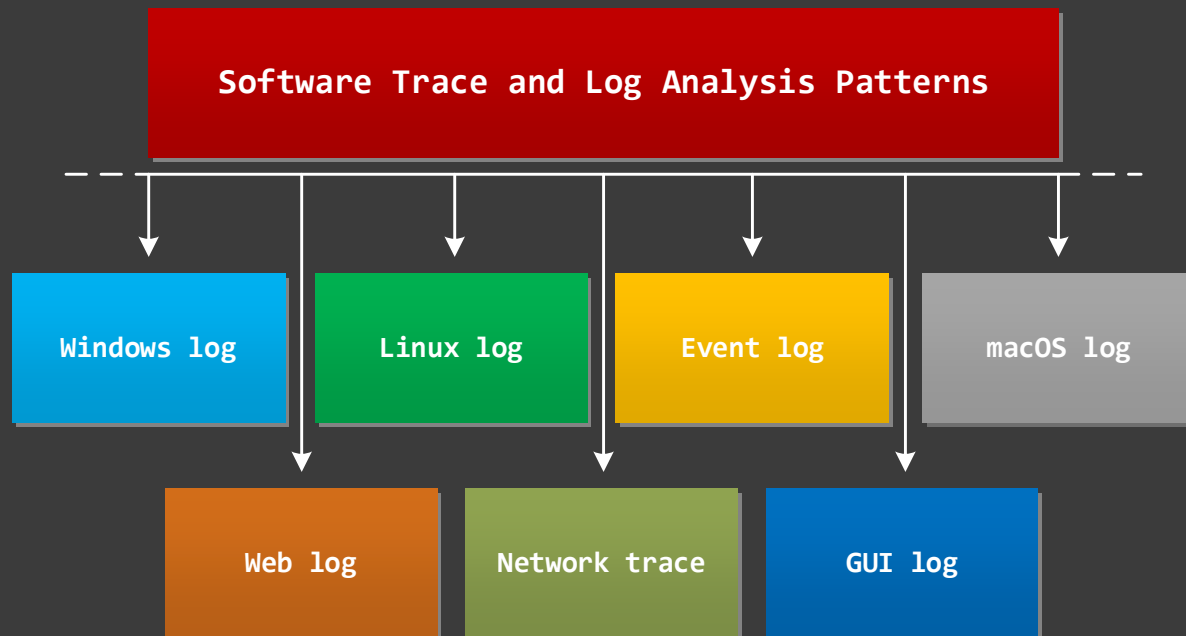


# Pattern Hierarchy

- 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

Related Patterns

**Basic Facts**  
**Activity Region**

## ⦿ Problem Description

A **user Test123** **authentication** failed  
basic fact index

## ⦿ Narrowing:



# 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

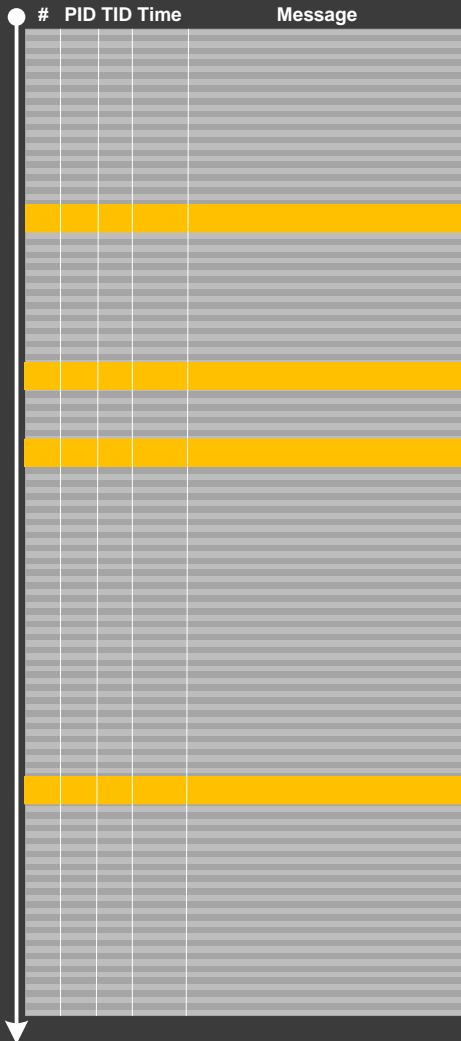
-----

[...]  
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 ↓

Time



```
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**

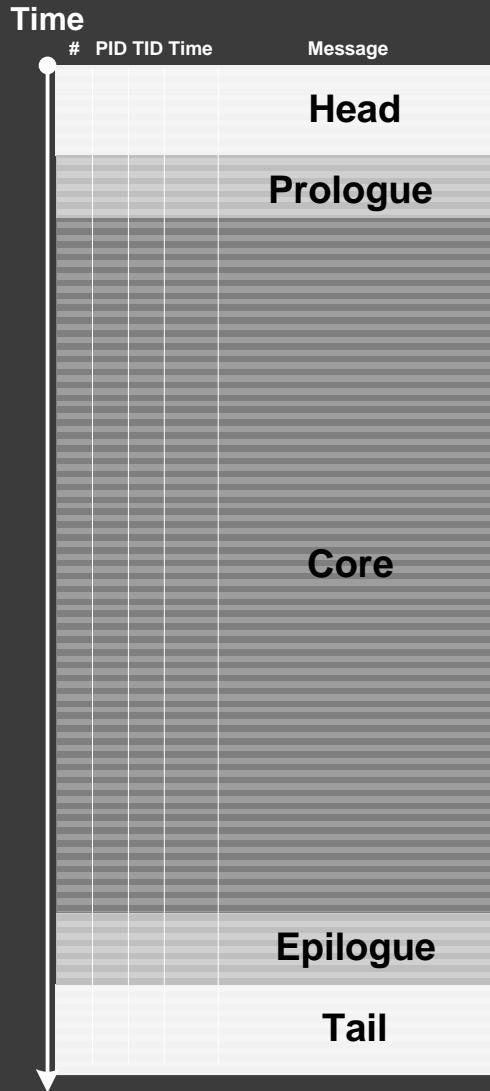




# Trace as a Whole

- 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



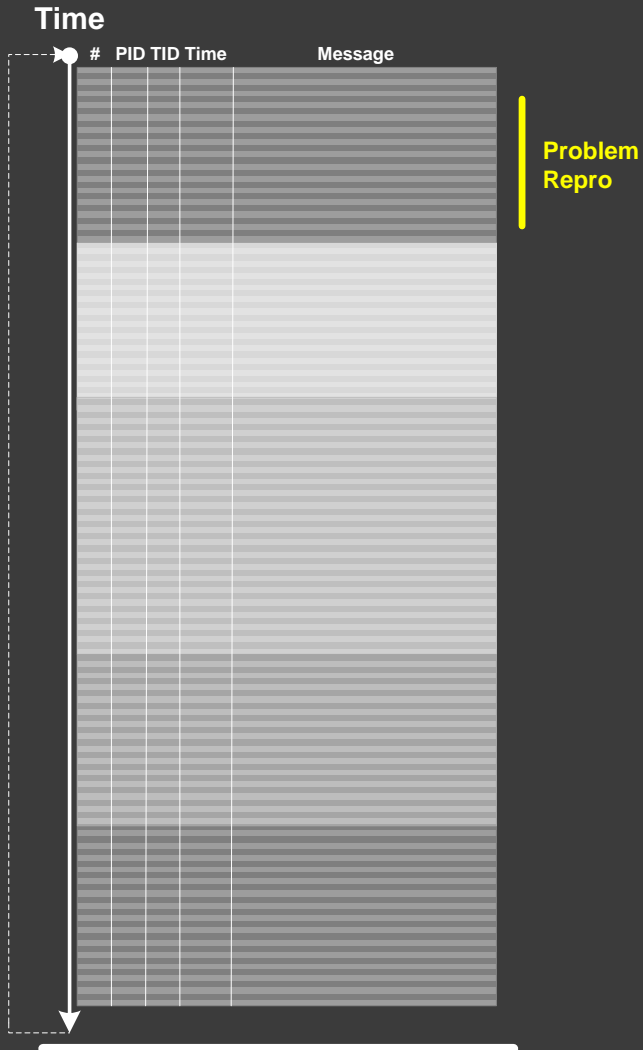
## Related Patterns

**Significant Event**  
**Truncated Trace**  
**Adjoint Thread**

# Circular Trace ↓

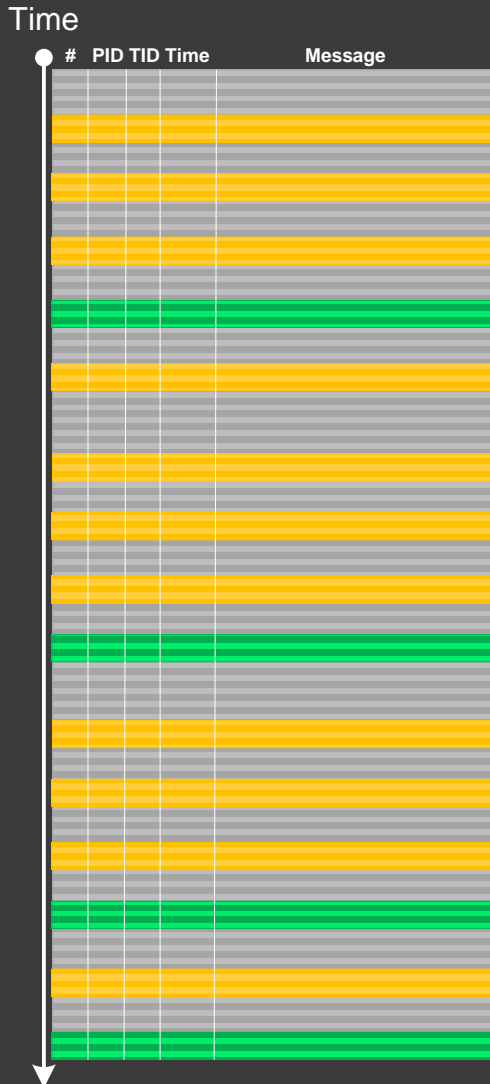
Related Patterns

Focus of Tracing



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

# Message Density



## Related Patterns

Intra-correlation  
Focus of Tracing  
Relative Density  
Partition

$$D_1 > D_2$$

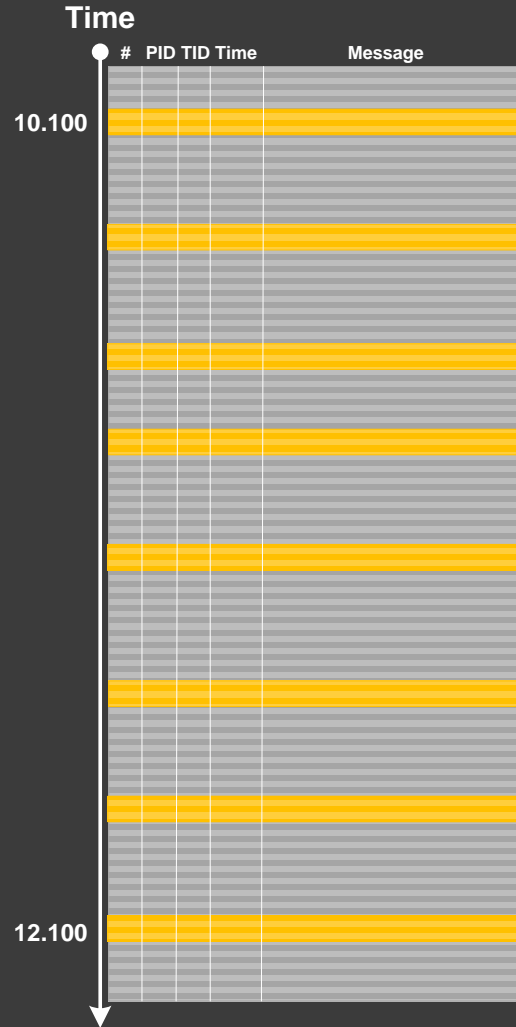
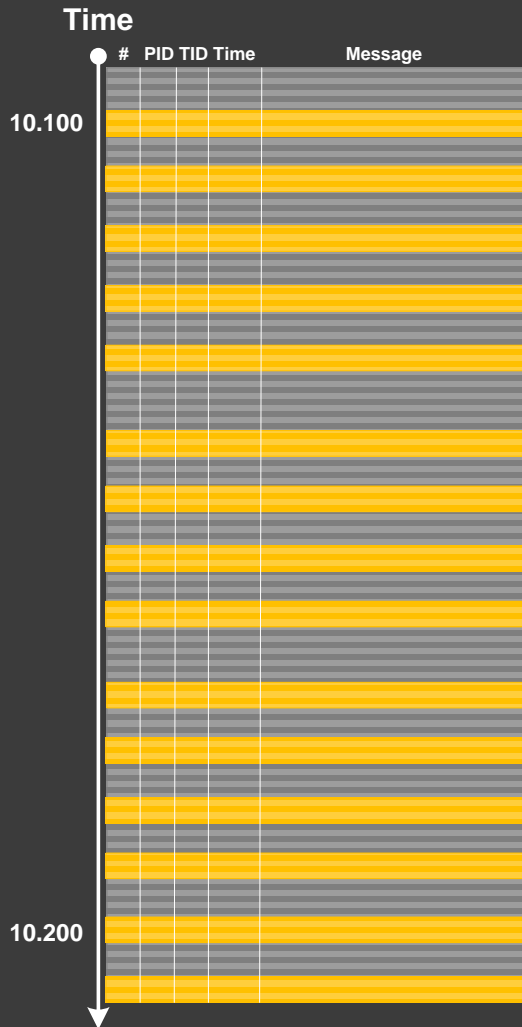
Similar relative density for 2 traces may show correlation:

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

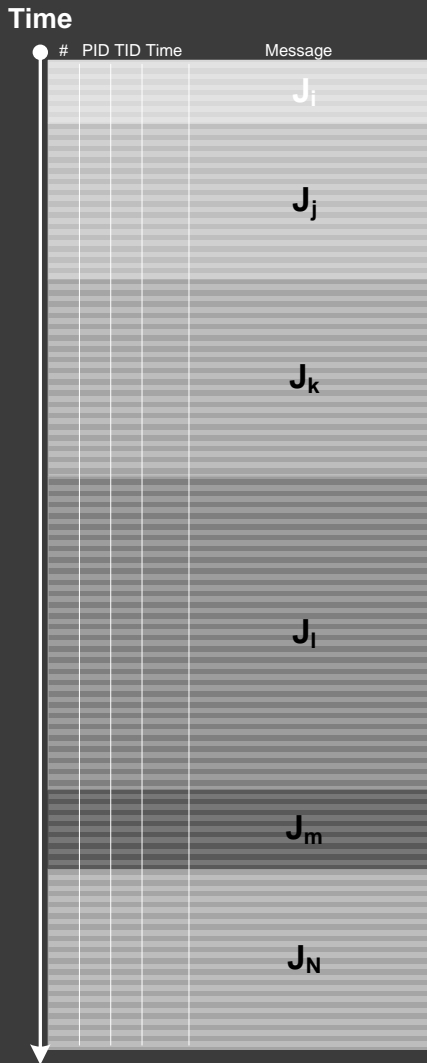
For correlated messages different densities from 2 traces may show different partition or system conditions:

$$D_{11} \gg D_{12}$$

# Message Current ↓



# Trace Acceleration



## Related Patterns

**Activity Region**  
**Message Current**  
**Thread of Activity**  
**Adjoint Thread of Activity**

Message current  $J_i < J_j, i < j < N$

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

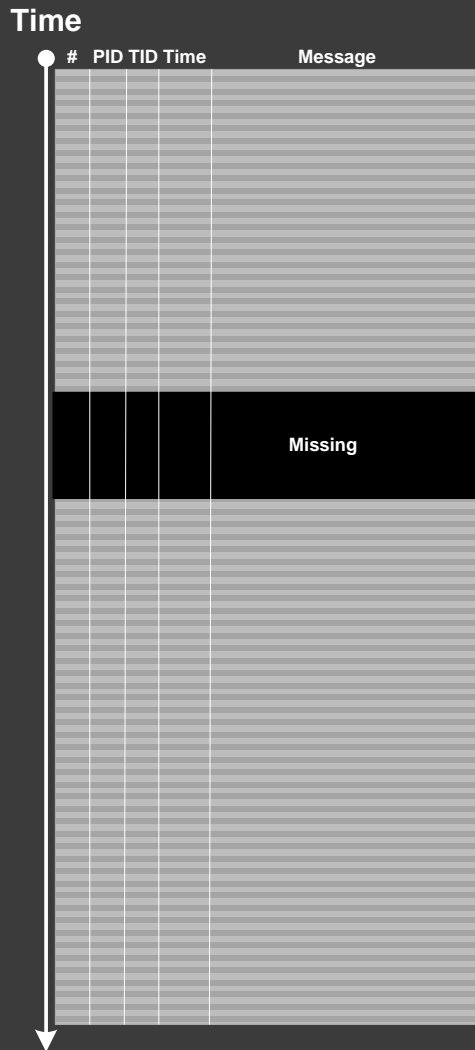
Always open a trace before sending to someone else

## Related Patterns

**Truncated Trace**  
**No Activity**  
**Missing Component**



# Missing Component

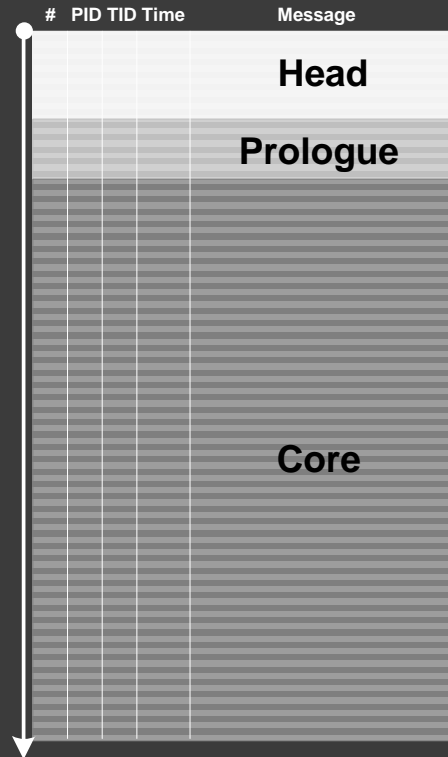
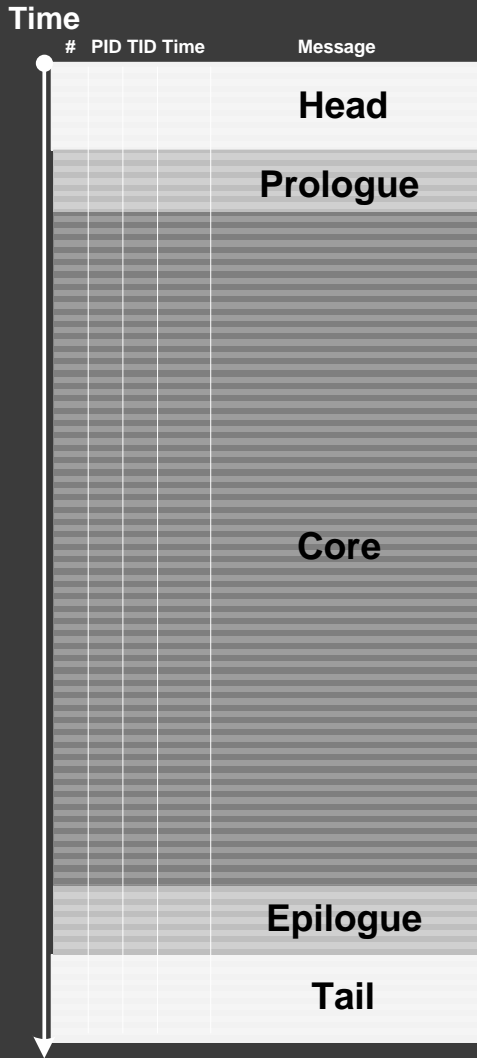


## Related Patterns

**Discontinuity**  
**Inter-Correlation**  
**No Activity**



# Truncated Trace

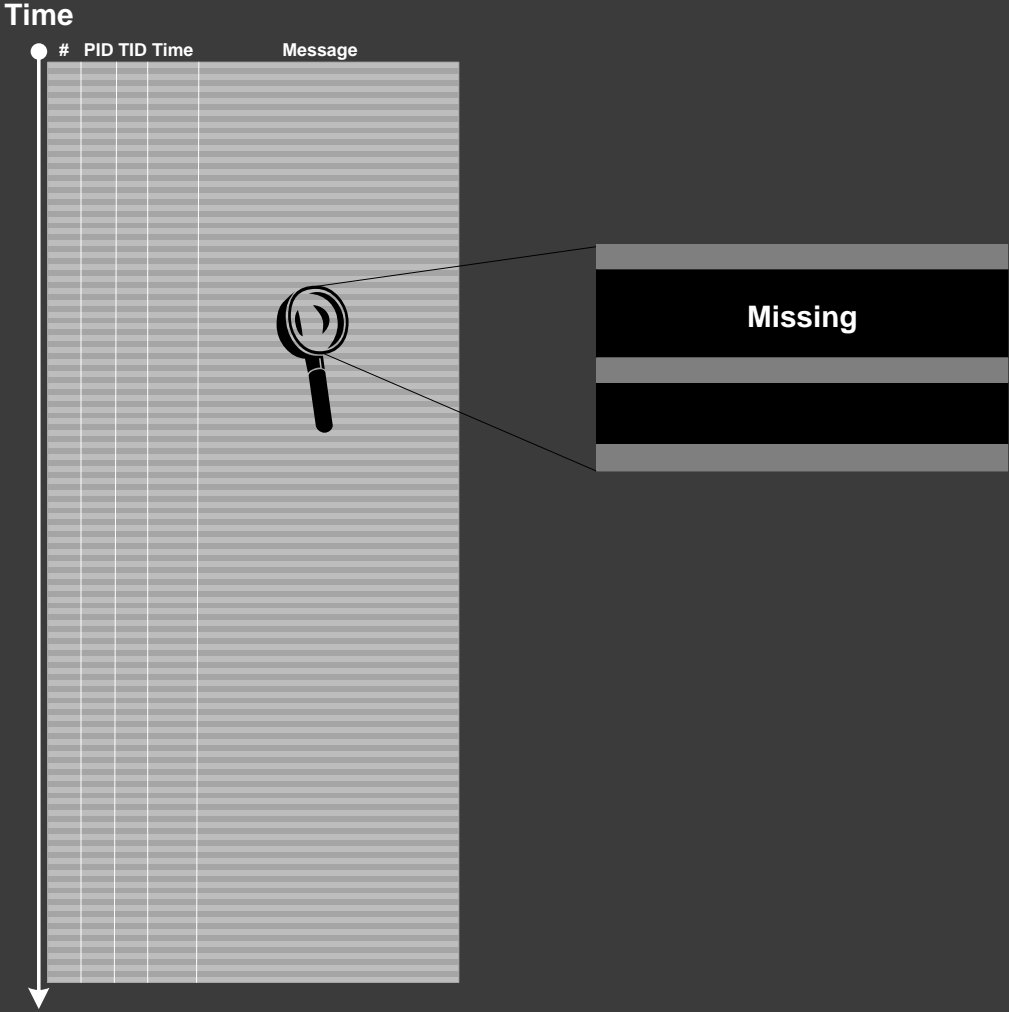


## Related Patterns

- Partition
- Anchor Messages
- Missing Component



# Sparse Trace



Related Patterns

Missing Component  
Visibility Limit

PLOT

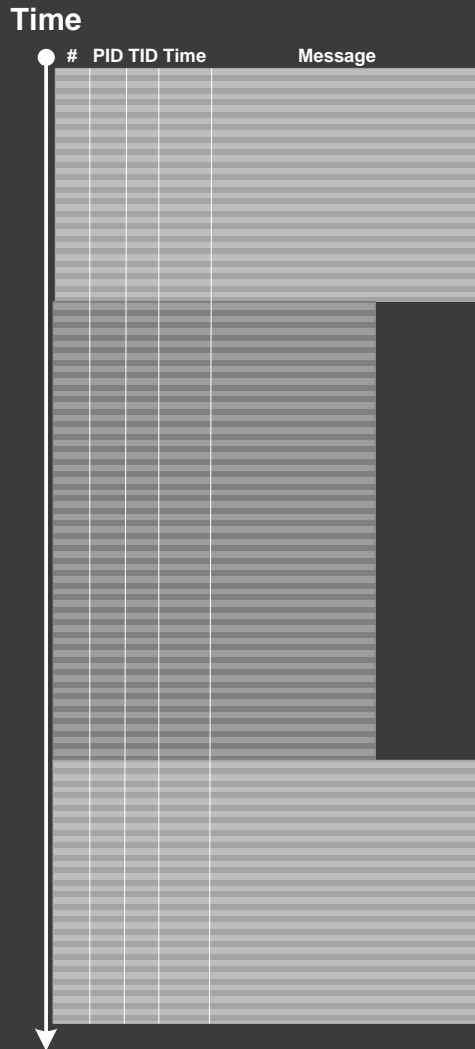
# Large Scale Patterns

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

# Bird's Eye Binary View

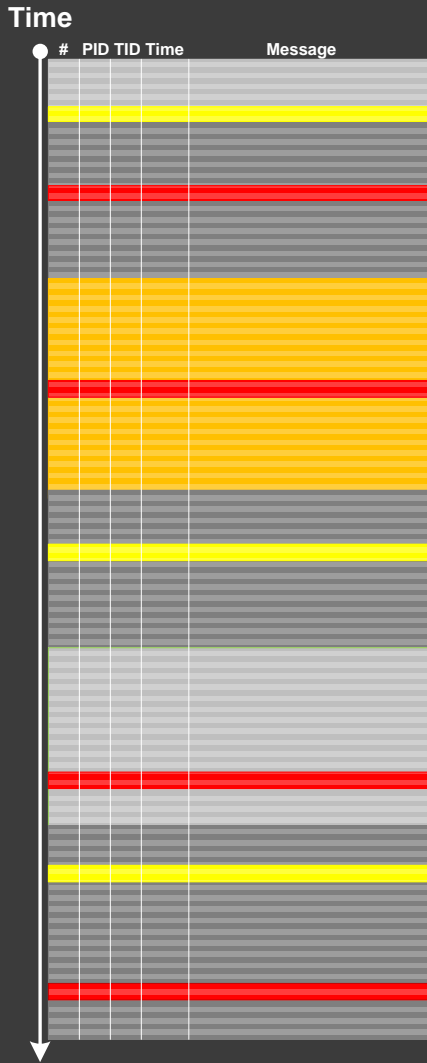


# Characteristic Message Block

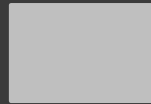




# Background Components



Background:



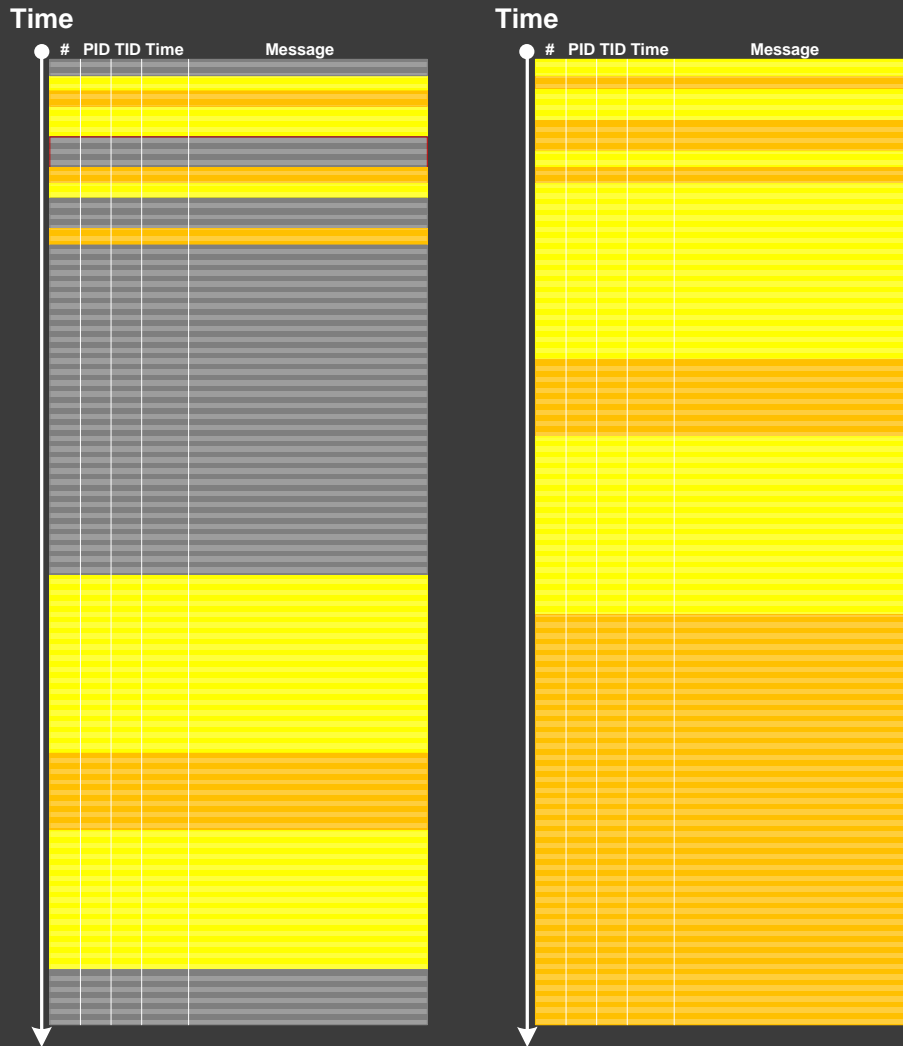
Foreground:



Related Patterns

**Foreground Components**

# Foreground Components

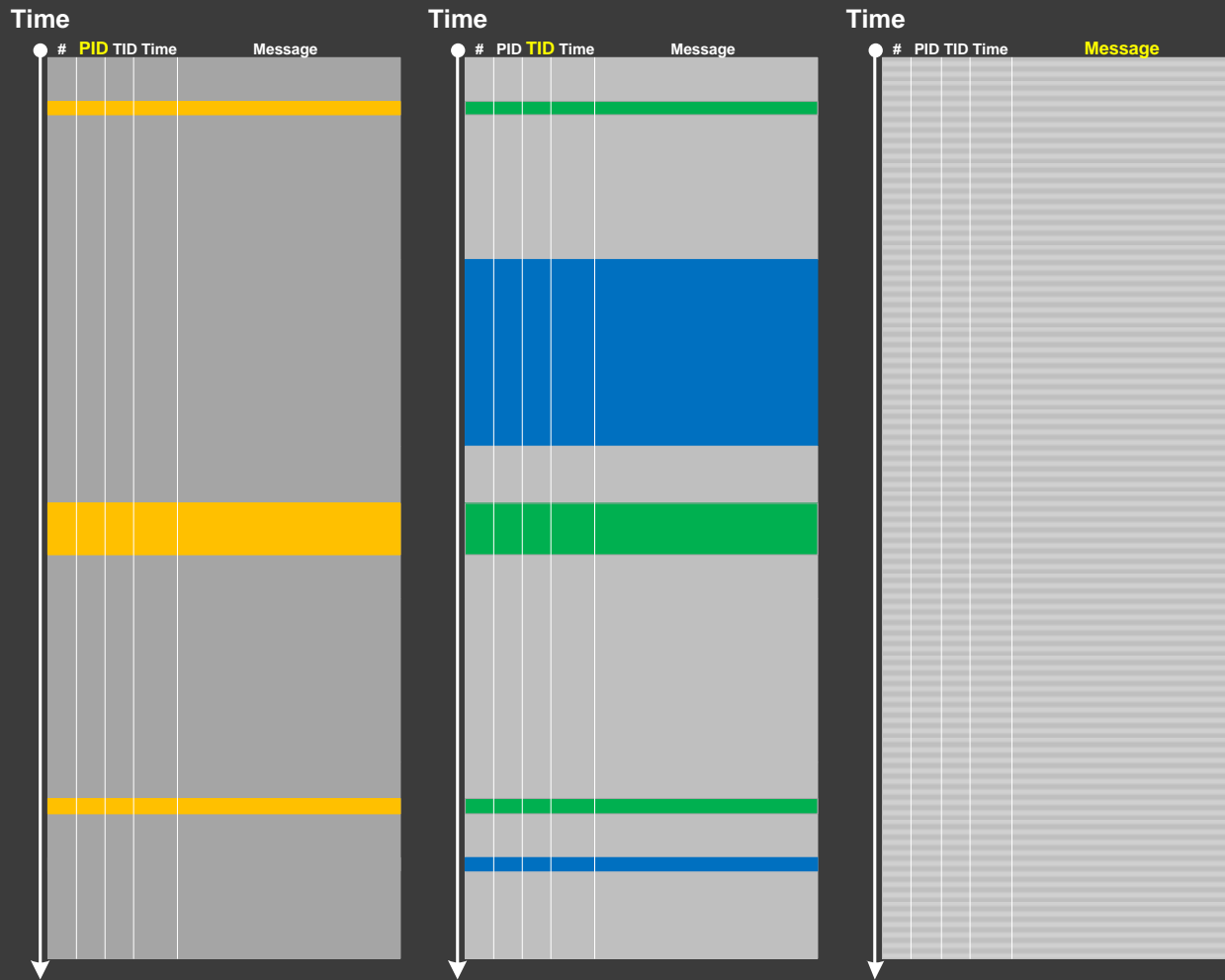


Related Patterns

**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)

```
[-] FuncA()  
{  
  [+]  
  FuncAA() { ... }  
  [+]  
  FuncAB() { ... }  
}
```

```
[-] FuncA()  
{  
  [-] FuncAA()  
  {  
    [+]  
    FuncAAA() { ... }  
  }  
  [-] FuncAB()  
  {  
    [+]  
    FuncABA() { ... }  
  }  
}
```

```
[-] FuncA()  
{  
  [-] FuncAA()  
  {  
    [-] FuncAAA()  
    {  
    }  
  }  
  [-] FuncAB()  
  {  
    [-] FuncABA()  
    {  
      [-] FuncABAA()  
      {  
      }  
      [-] FuncABAB()  
      {  
        [-] FuncABABA()  
        {  
        }  
      }  
    }  
  }  
}
```

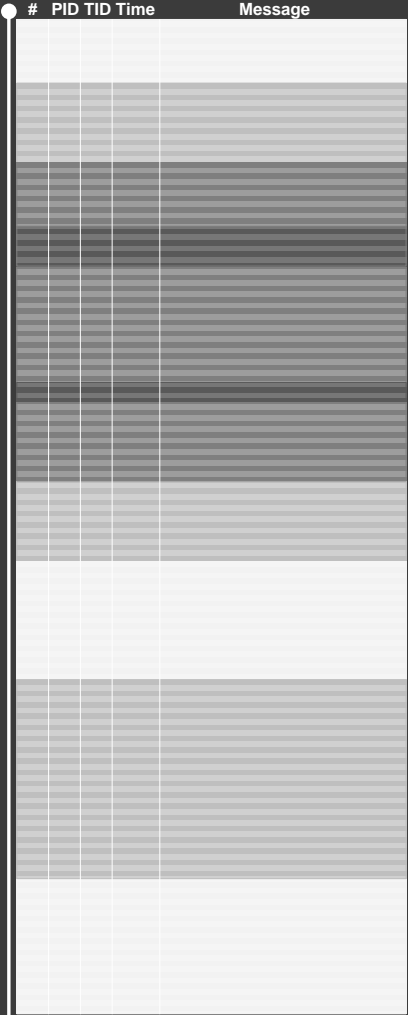
Visual Studio

# Trace Frames

## Related Patterns

- Thread of Activity
- Adjoint Thread
- Truncated Trace
- Discontinuity

Time



# Activity Patterns

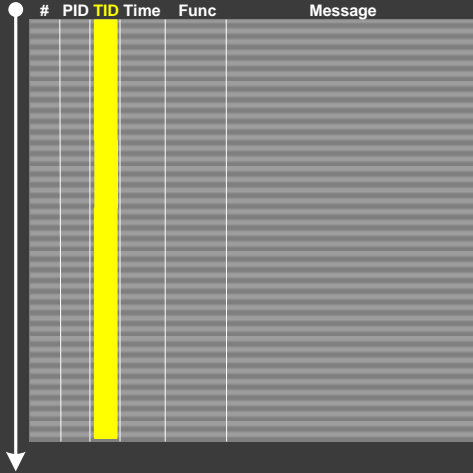
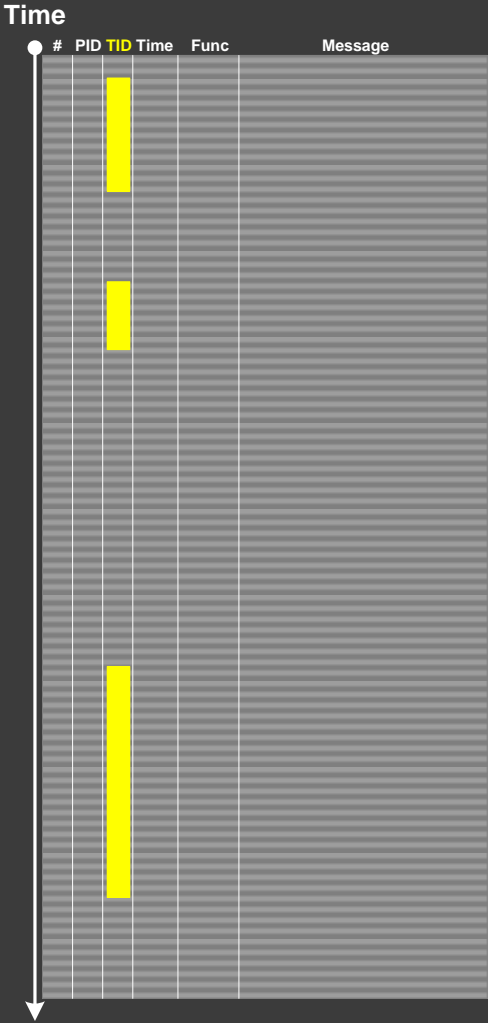
- ◎ Thread of Activity ↓
- ◎ Adjoint Thread of Activity ↓
- ◎ No Activity
- ◎ Activity Region
- ◎ Discontinuity ↓
- ◎ Time Delta ↓
- ◎ Glued Activity
- ◎ Break-in Activity ↓
- ◎ Resume Activity ↓
- ◎ Data Flow ↓



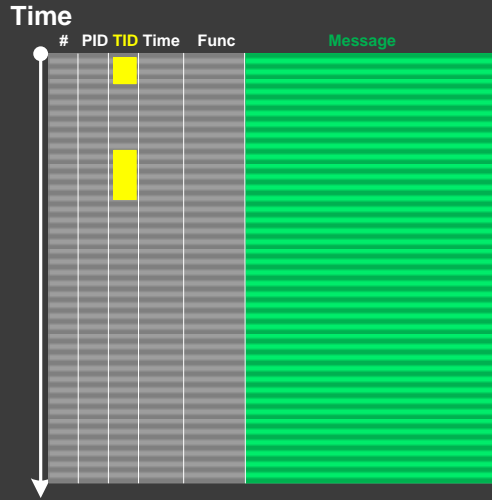
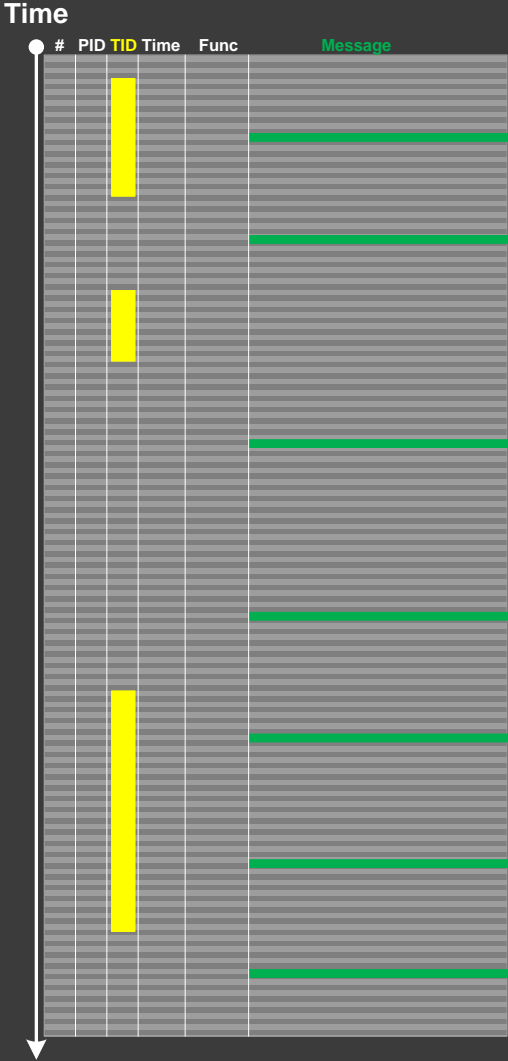
# Thread of Activity ↓

Related Patterns

**Discontinuity**  
**Sparse Trace**



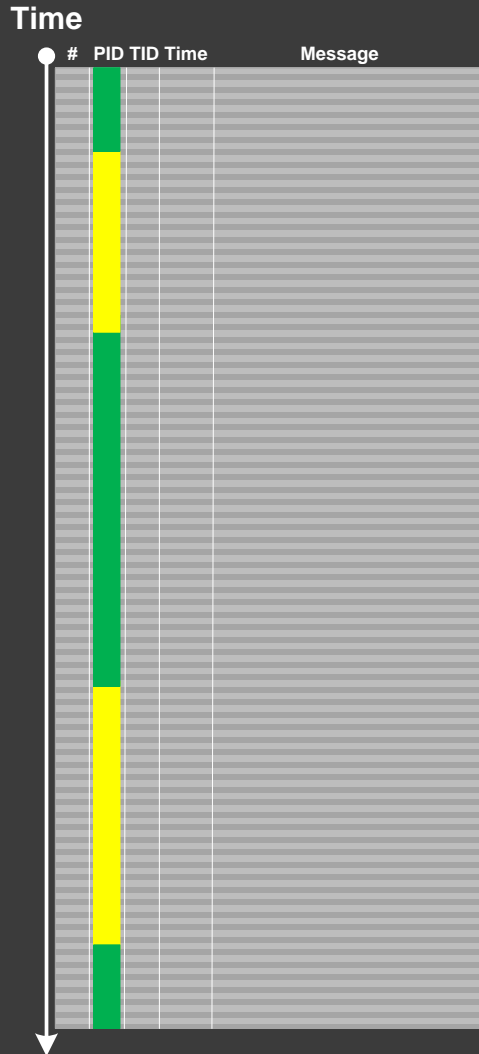
# Adjoint Thread of Activity ↓



Related Patterns

**Thread of Activity**  
**Message Invariant**

# No Activity



We expect this process

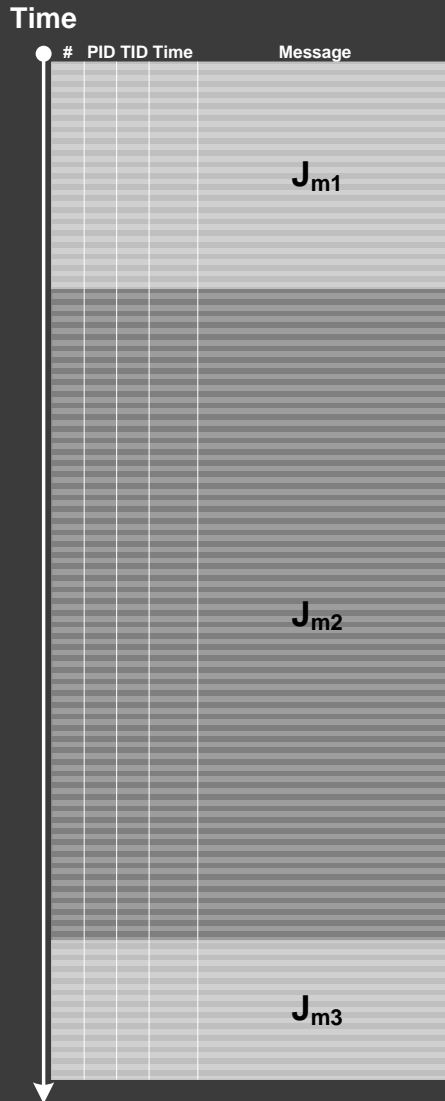
## Possible causes:

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

## Related Patterns

Discontinuity  
Sparse Trace  
Missing Component

# Activity Region

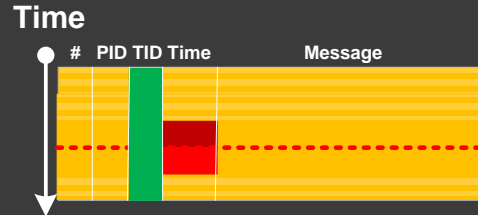
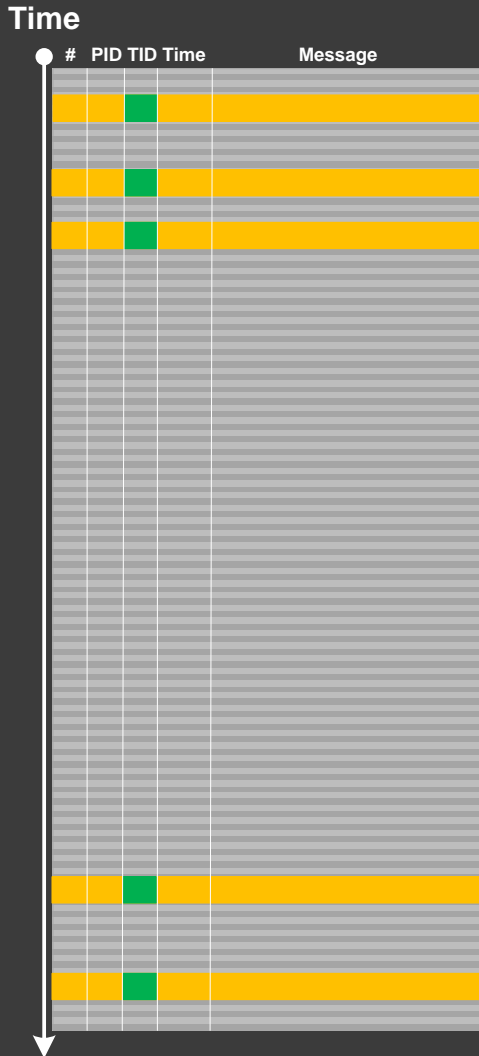


## Related Patterns

Message Current  
Characteristic Message Block

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

# Discontinuity ↓



Related Patterns

- Thread of Activity
- Missing Component
- Sparse Trace

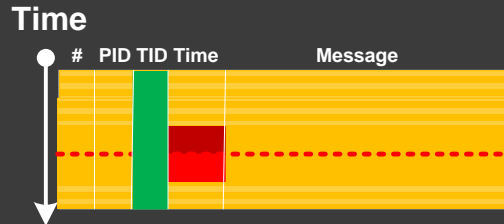
## Possible causes:

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

# Time Delta ↓

## Related Patterns

**Basic Facts**  
**Thread of Activity**  
**Discontinuity**  
**Significant Event**



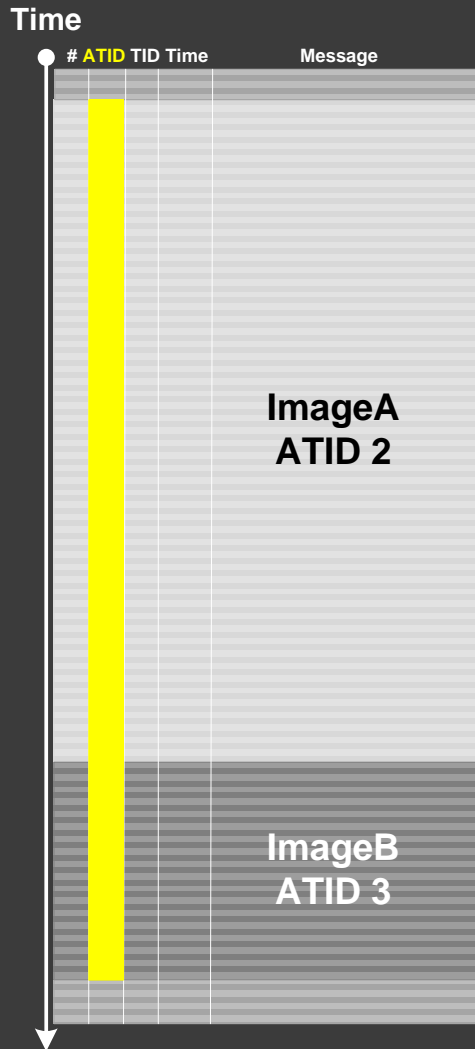
#	Module	PID	TID	Time	File	Function	Message
6060	dllA	1604	7108	10:06:21.746	fileA.c	DllMain	DLL_PROCESS_ATTACH
24480	dllA	1604	7108	10:06:32.262	fileA.c	LaunchApp	Exec Path: C:\Program Files\CompanyA\appB.exe

30 seconds of discontinuity till the end of full trace

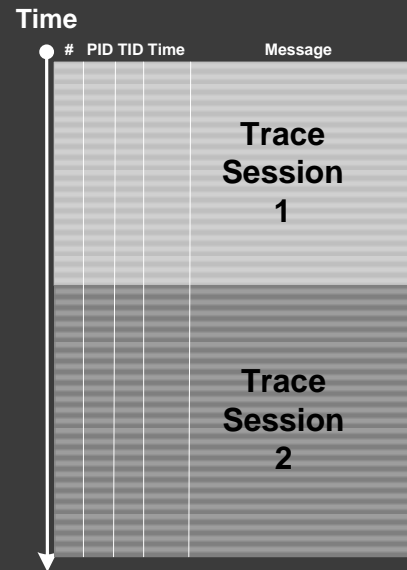
# Glued Activity

Related Patterns

Adjoint Thread



ATID: Adjoint Thread ID











# Message Patterns

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



# Poetry of Software Traces

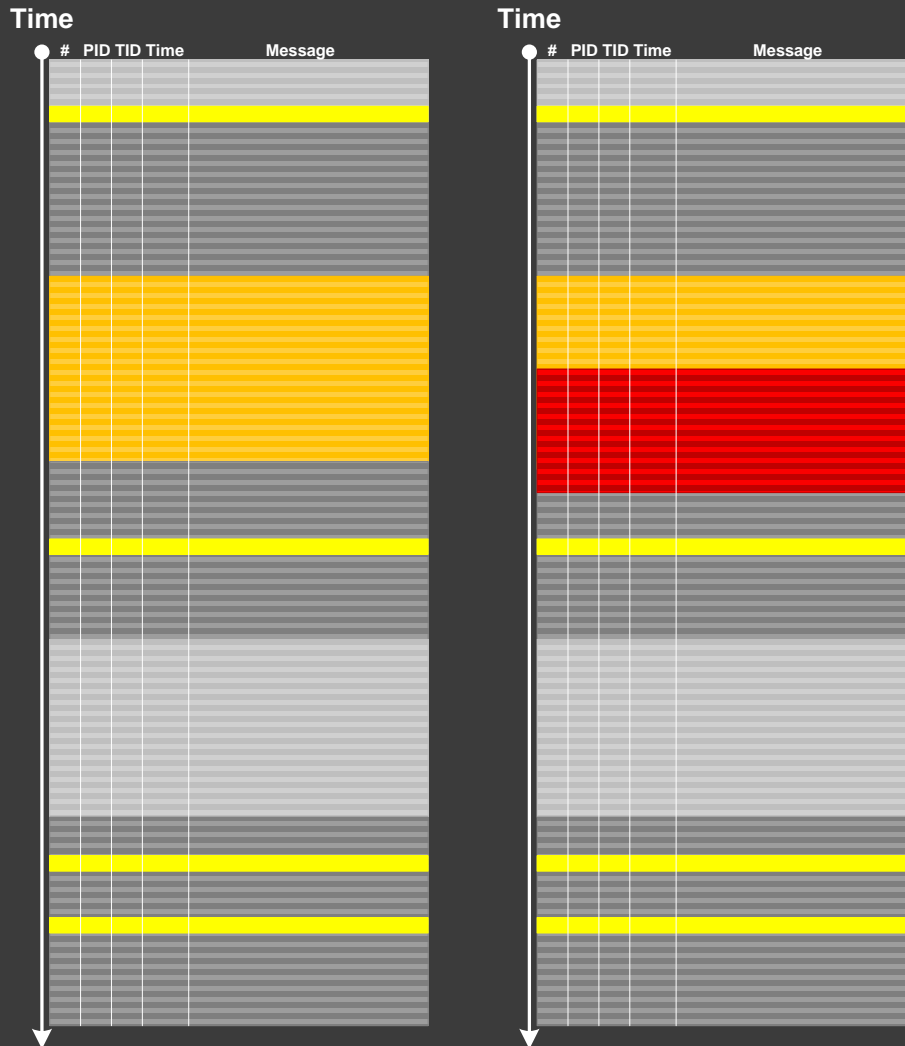
*“Capturing delicate moments, one gives birth to a poetry of traces ...”*

Ange Leccia, Motionless Journeys, by Fabien Danesi

# Defamiliarizing Effect

Related Patterns

**Characteristic Message Block  
Activity Region**





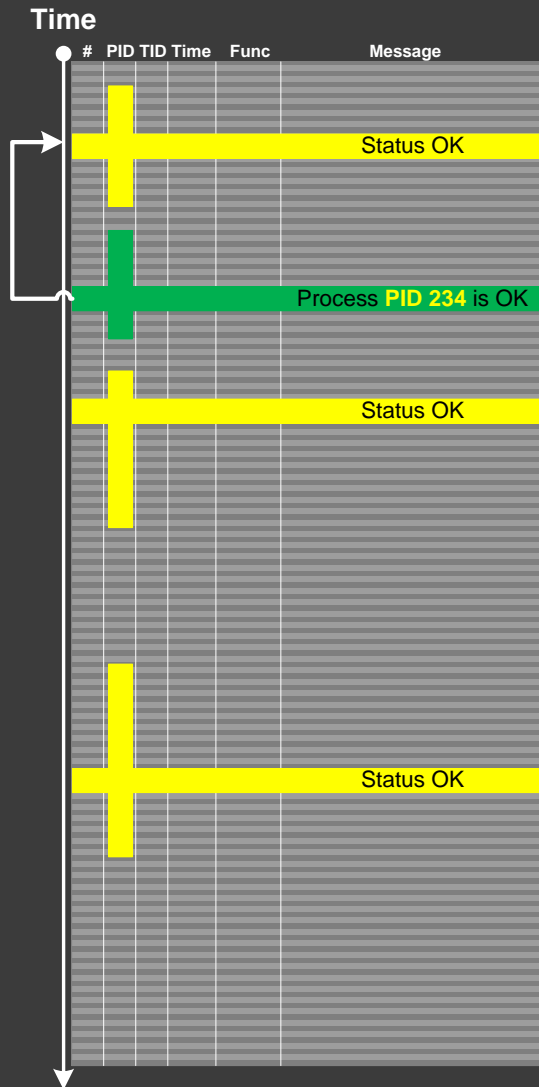




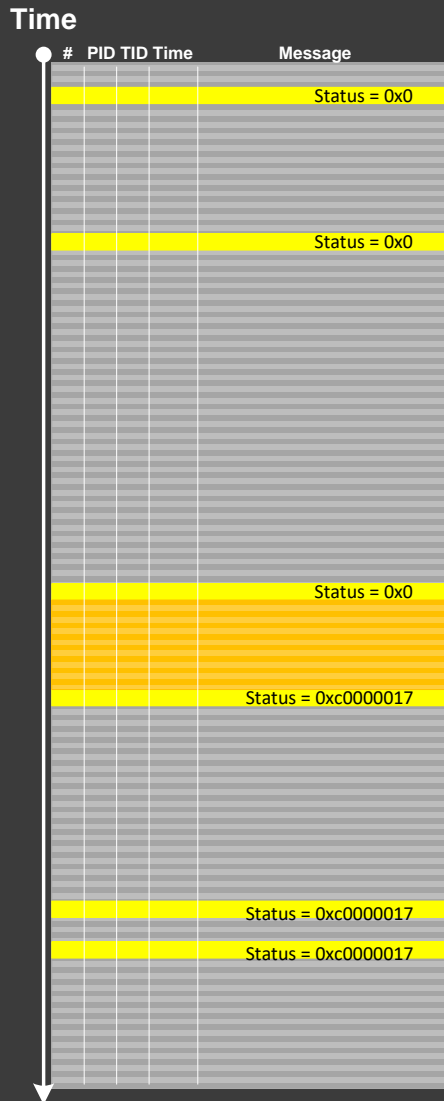
# Diegetic Messages

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 0x00A83D30 data ([...]) version 0x4  
[...]
```

```
#      Module  PID  TID  Time      Message
-----
[...]  
4793 ModuleA  2376 8480 09:22:01.947 CreateObject: pObject 0x00BA4E20 data ([...]) version 0x5  
[...]
```

# 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

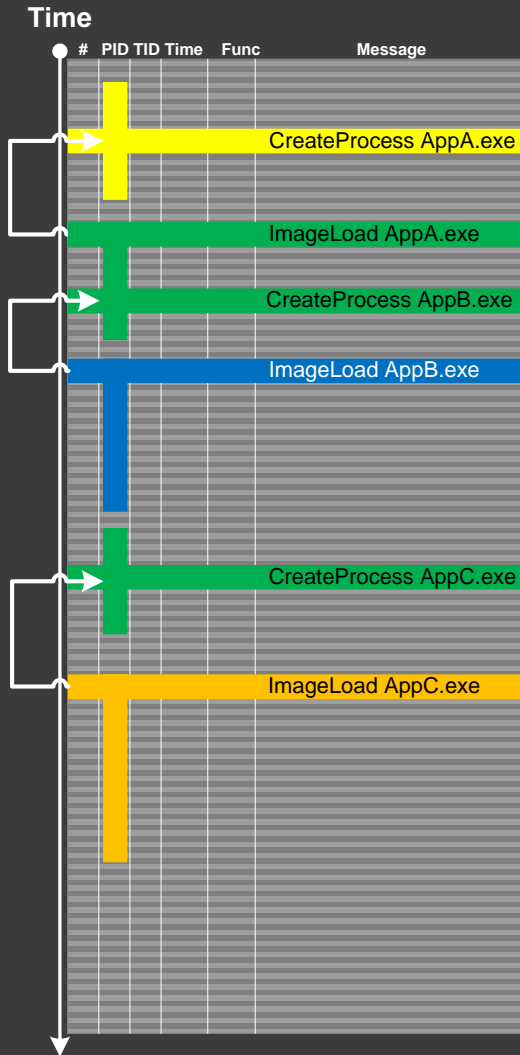
**Message Invariant**  
**Adjoint Thread**

#	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

Related Patterns

Adjoint Thread



#	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
[...]		

# 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 0x000000000000087C  
[...]  
33132 ModuleA  4180 2130 LoadImage: \Device\HarddiskVolume2\Windows\System32\calc.exe PID 0x0000000000001054  
[...]
```



# Counter Value

## Related Patterns

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

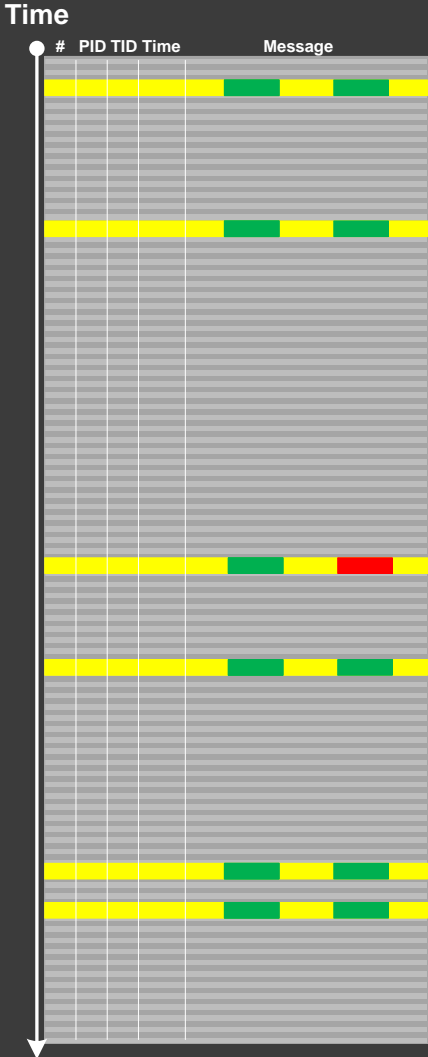
[Module Variable](#)

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**

# Abnormal Value





# 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

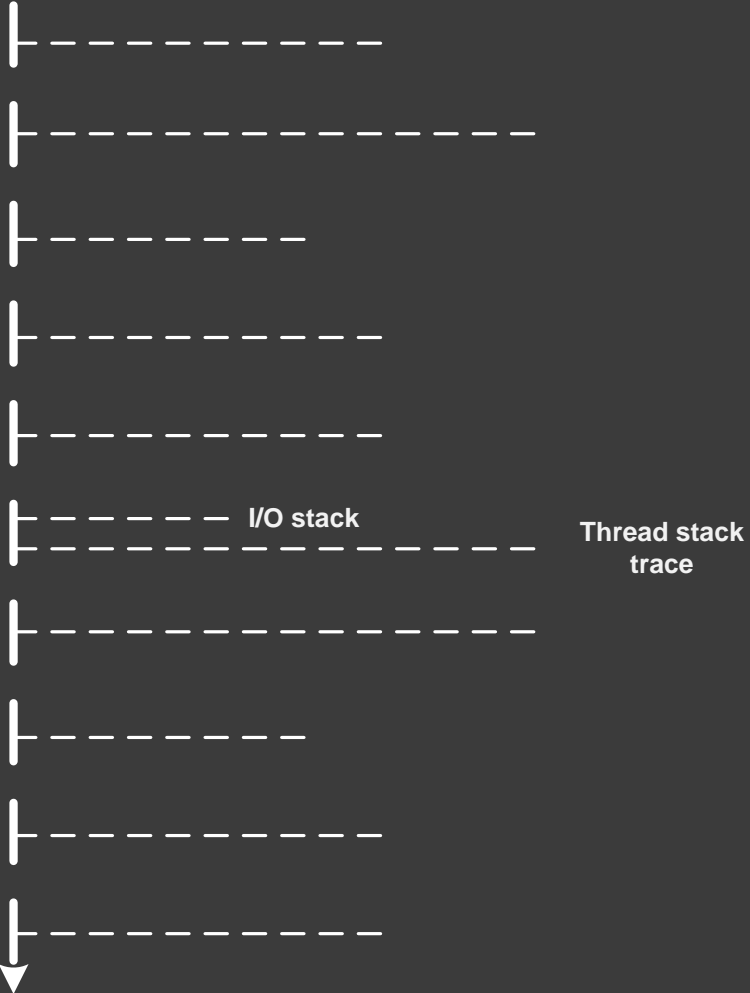
[-] activity is undetected or not present

# Fiber Bundle

Related Patterns

Exception Stack Trace

Trace  
messages



# Incomplete History

## Related Patterns

**Opposition Messages**  
**Sparse Trace**  
**Truncated Trace**  
**Master Trace**

Code:

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

# 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
[...]					



# Intra-Correlation

## Related Patterns

### Basic Facts Activity Regions

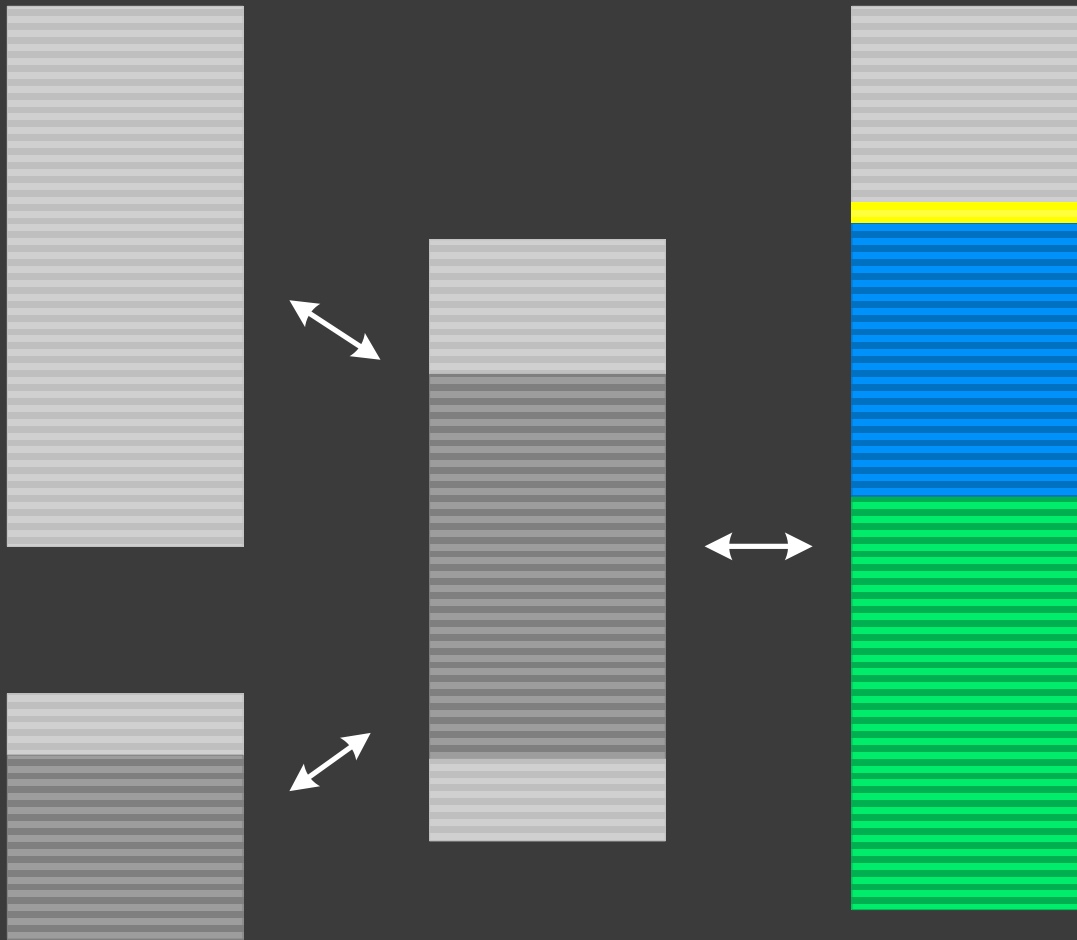
```
Handle: 00050586 Class: "Application A Class" Title: ""
Title changed at 15:52:4:3 to "Application A"
Title changed at 15:52:10:212 to "Application A - File1"
[...]
Process ID: 89c
Thread ID: d6c
[...]
Visible: true
Window placement command: SW_SHOWNORMAL
Placement changed at 15:54:57:506 to SW_SHOWMINIMIZED
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

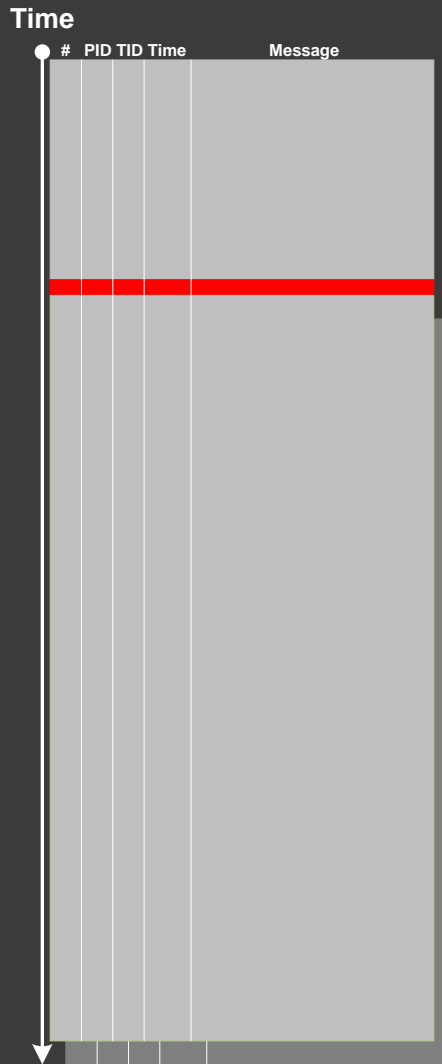
# Master Trace



## Related Patterns

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

# Bifurcation Point

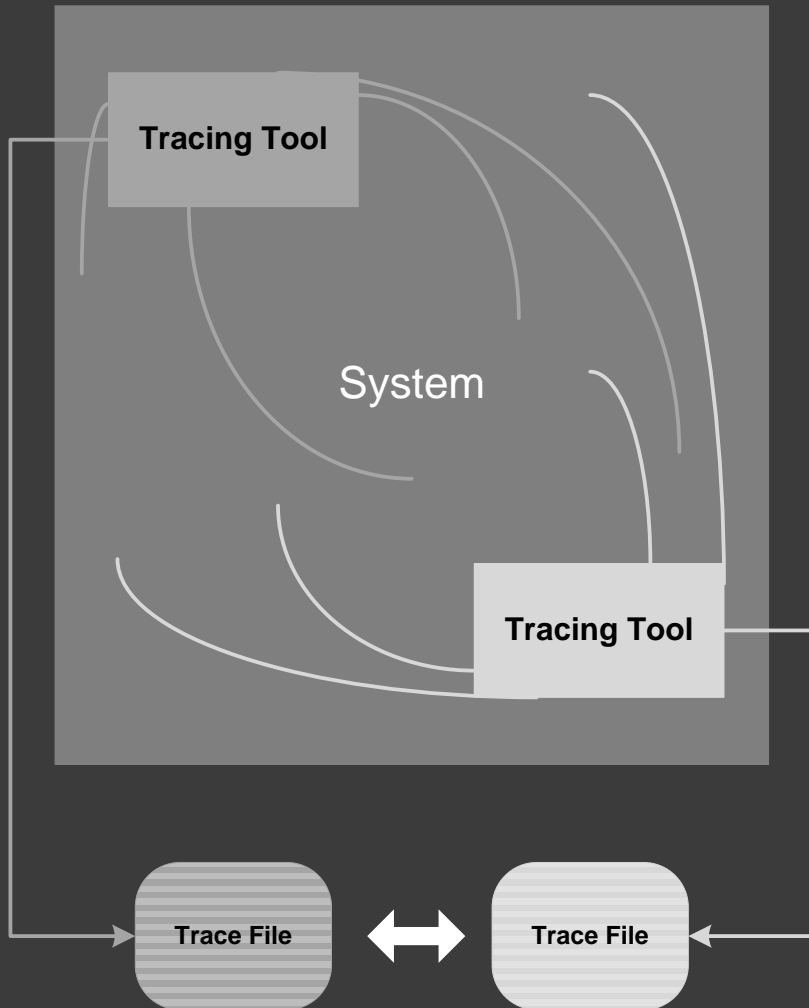


## Software Trace Diagrams

#	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	<b>Query result: Y</b>
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



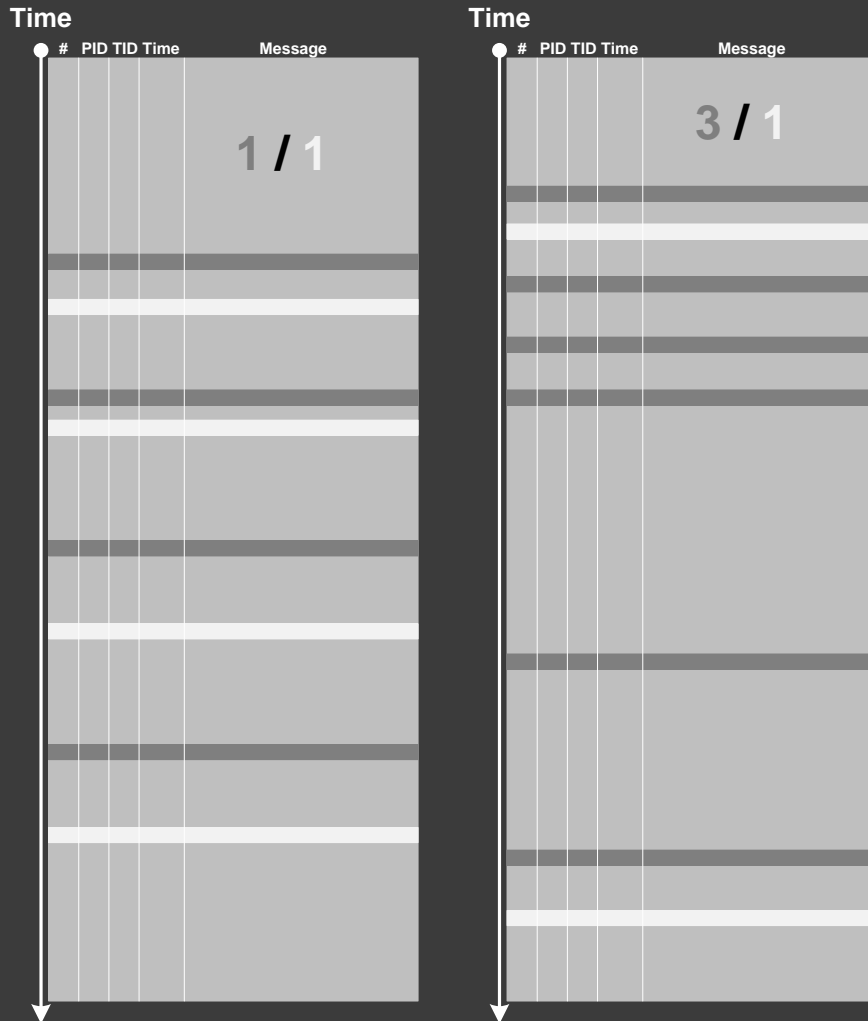
## Related Patterns

**Intra-Correlation**  
**Basic Facts**  
**Discontinuity**  
**Sparse Trace**

# Relative Density

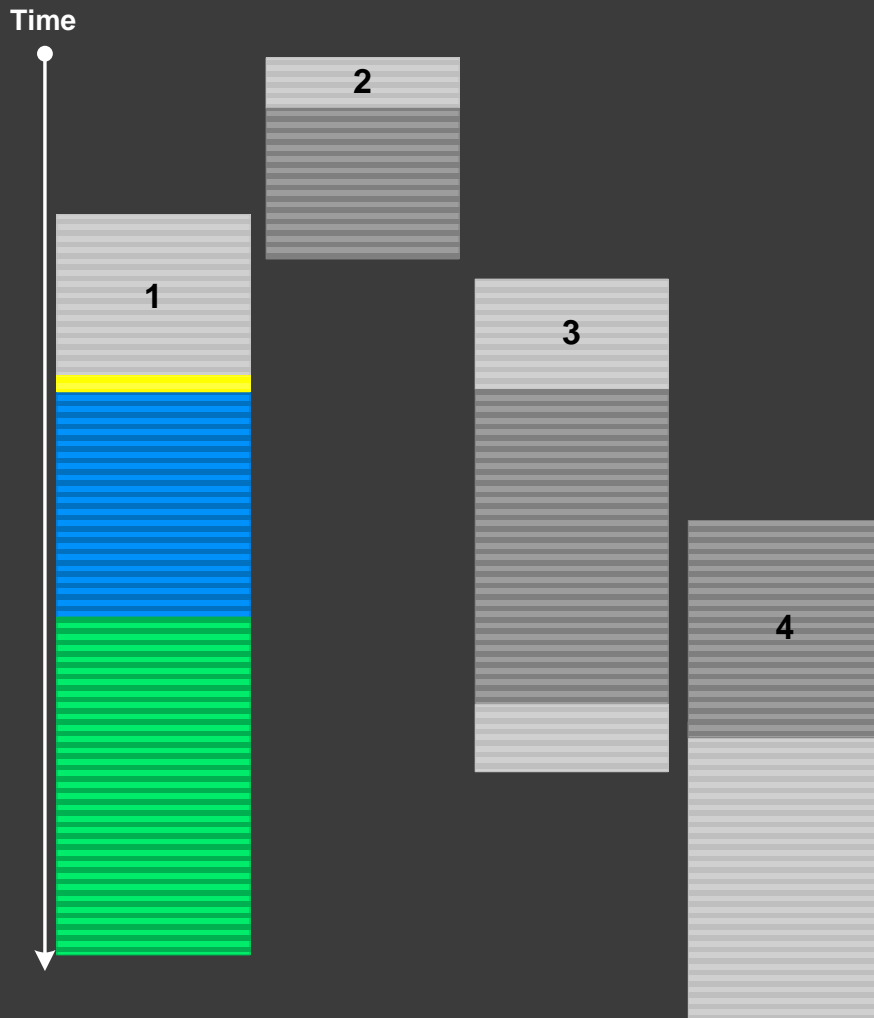
Related Patterns

Message Density





# News Value



## Related Patterns

**Inter-Correlation**  
**Basic Facts**  
**Master Trace**

# Impossible Trace

Related Patterns

**Sparse Trace**

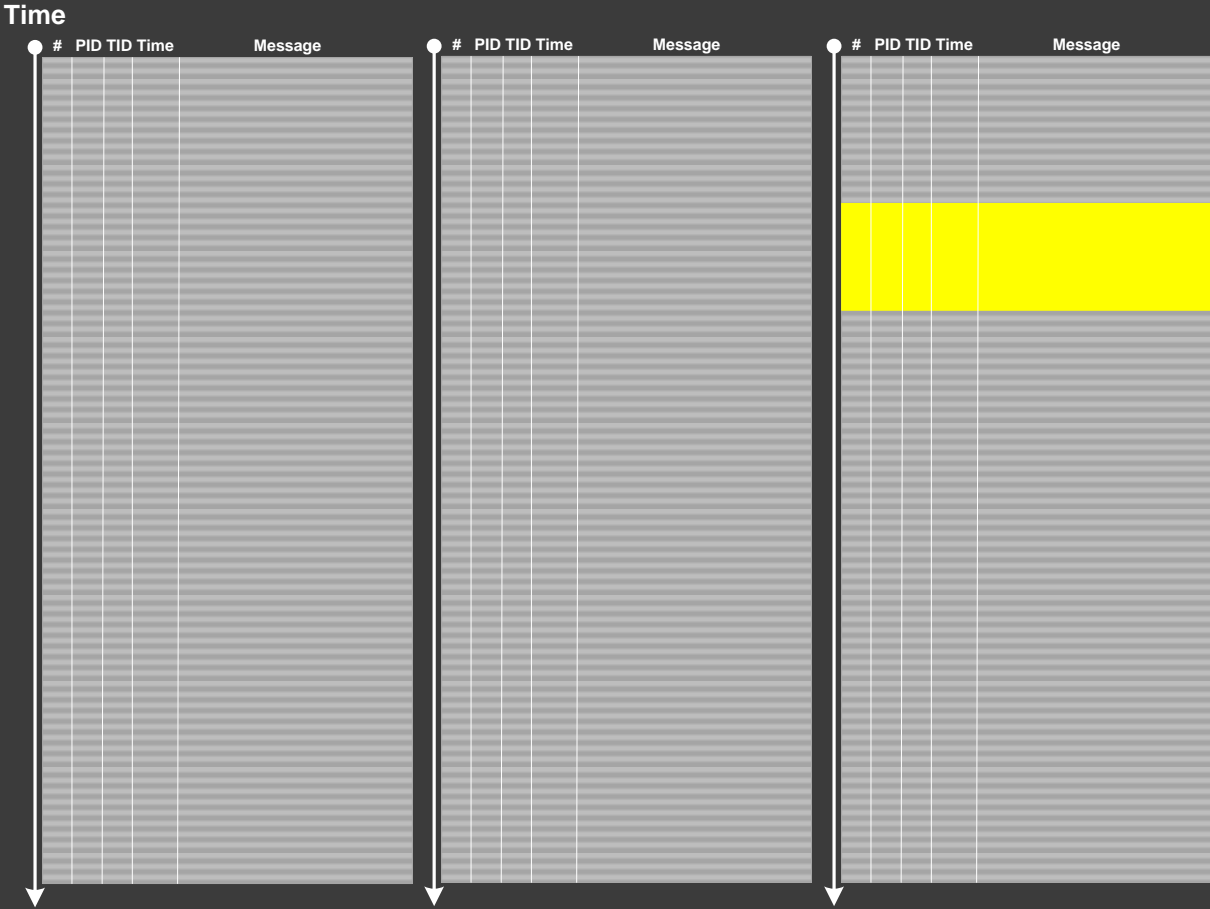
```
#      Module  PID TID Message
-----
[...]  
1001 ModuleA 202 404 foo: start  
1002 ModuleA 202 404 foo: end  
[...]
```

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

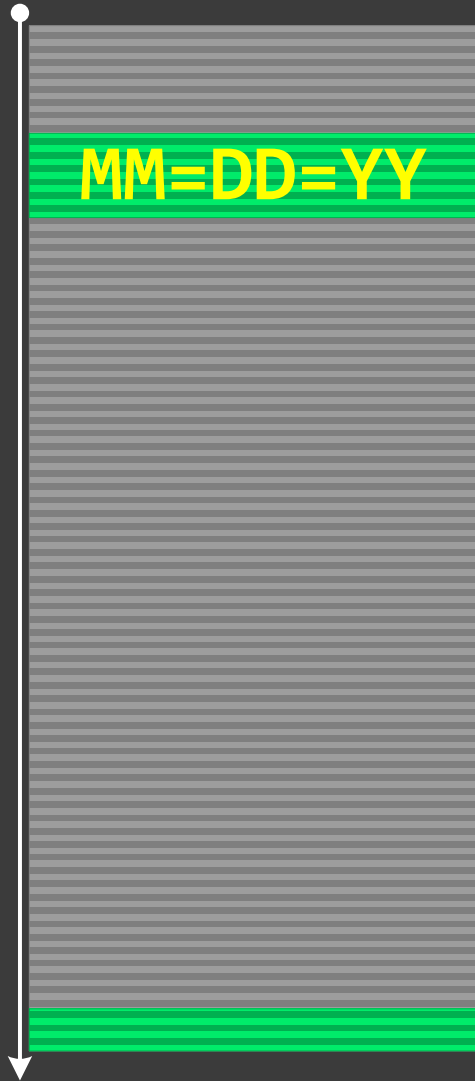
# Split Trace

Related Patterns

Circular Trace



# 12.12.12



## Related Patterns

**Adjoint Thread**  
**Discontinuity**  
**Time Delta**  
**Periodic Message Block**



# Q&A

Please send your feedback using the contact form on [PatternDiagnostics.com](https://PatternDiagnostics.com)

Thank you for attendance!