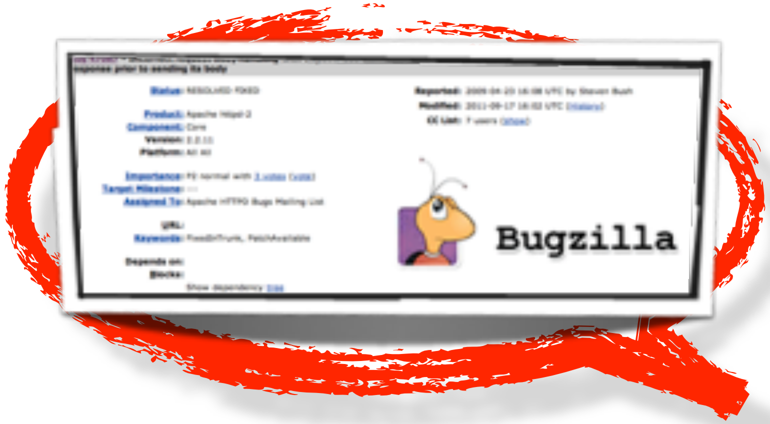
Integrated Impact Analysis for Managing Software Changes

Malcom Gethers, Bogdan Dit, Huzefa Kagdi,
Denys Poshyvanyk

WILLIAM
& MARY

Change Impact Analysis

Software change impact analysis aims at estimating the potentially impacted entities of a system due to a proposed change [Bohner and Arnold '96]



response prior to sending its body

Status: RESOLVED FIXED

Product: Apache httpd-2
Component: Core
Version: 2.2.11
Platform: All All

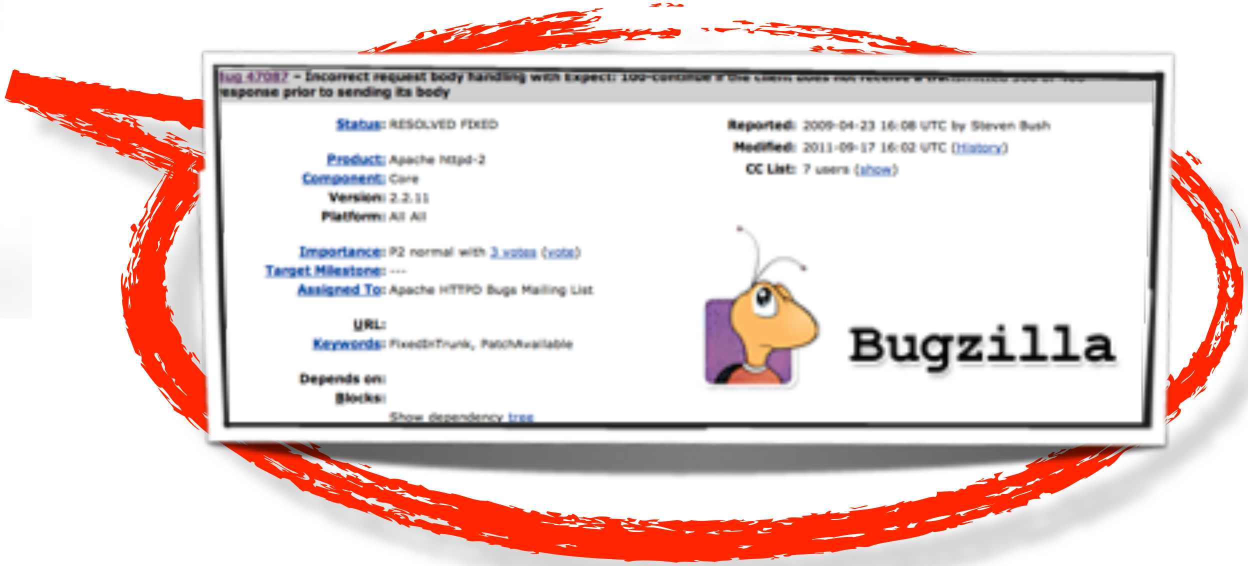
Importance: P2 normal with 3 votes (vote)
Target Milestone: ---
Assigned To: Apache HTTPD Bugs Mailing List

URL:
Keywords: FixedInTrunk, PatchAvailable

Depends on:
Blocks:
Show dependency tree

Reported: 2009-04-23 16:08 UTC by Steven Bush
Modified: 2011-09-17 16:02 UTC (History)
CC List: 7 users (show)

Impact Analysis (IA)



Bug 47087 – Incorrect request body handling with Expect: 100-continue if the client does not receive a transmitted 300 or 400 response prior to sending its body

Status: RESOLVED FIXED

Product: Apache httpd-2
Component: Core
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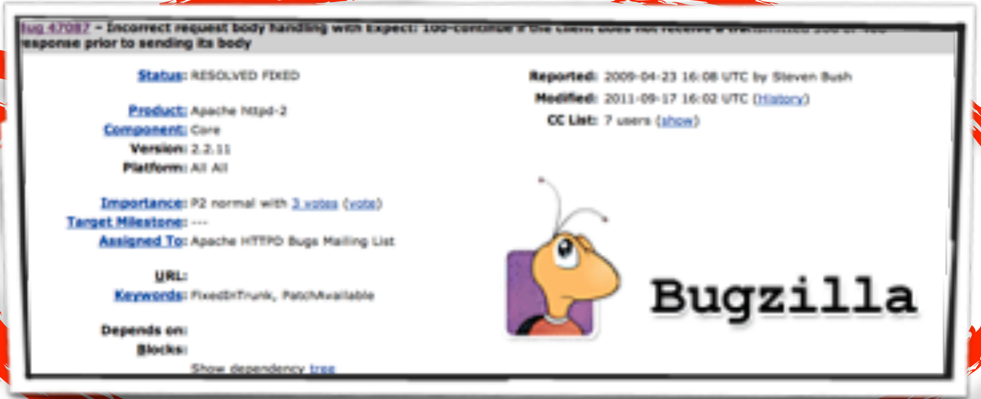

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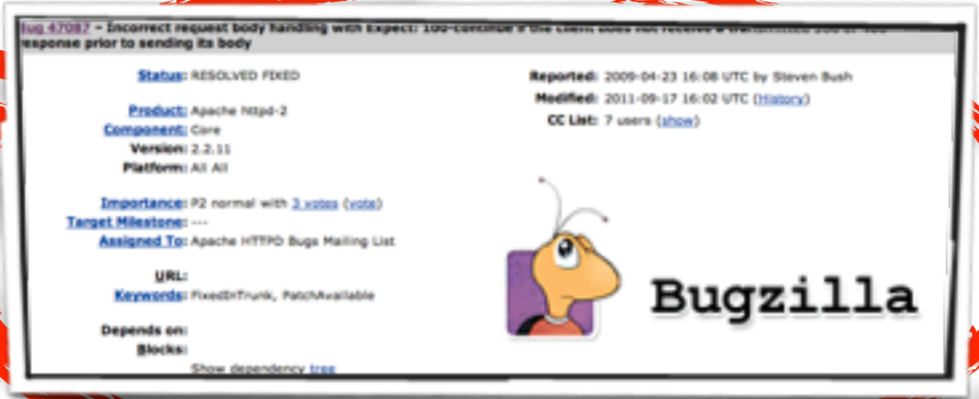

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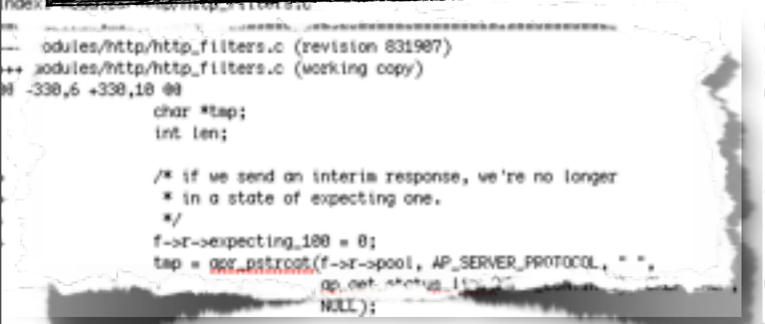
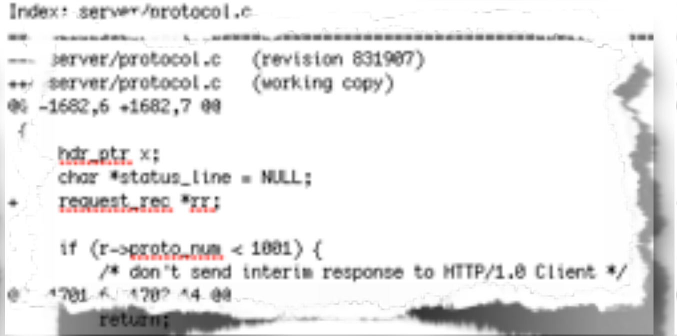
Impact Set



```
Index: modules/http/http_filters.c
===================================================================
--- modules/http/http_filters.c (revision 831907)
+++ modules/http/http_filters.c (working copy)
@@ -330,6 +330,10 @@
                 char *tmp;
                 int len;

+                /* if we send an interim response, we're no longer
+                 * in a state of expecting one.
+                 */
+                f->r->expecting_100 = 0;
                 tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                                   ap_get_status_line(200),
                                   NULL);
```



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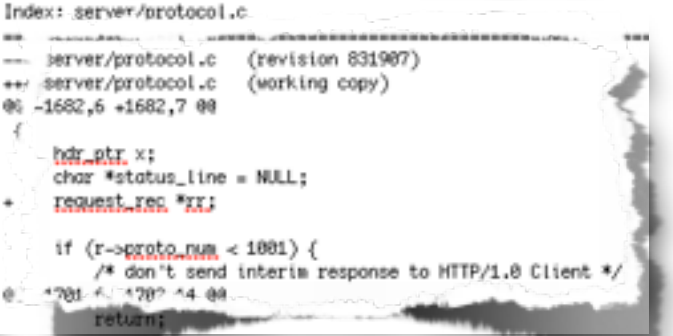
Index: server/protocol.c
===================================================================
--- server/protocol.c   (revision 831907)
+++ server/protocol.c   (working copy)
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```



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Related Work

Software change IA via Static and Dynamic Analysis

[Law and Rothermel ICSE'03] [Orso et al. ESEC/FSE'03] [Orso et al. ICSE'04] [Ren et al. OOPSLA'04]

Software change IA via Information Retrieval

[Canfora and Cerula MSR'06] [Hill et al. ASE'07] [Kagdi et al. WCRE'10] [Poshyvanyk et al. EMSE'09]

Software change IA via Mining Software Repositories

[Zimmermann et al. TSE'05] [Gall et al. ICSM'98] [Kagdi et al. WCRE'10] [Canfora and Cerula MSR'06]

Related Work

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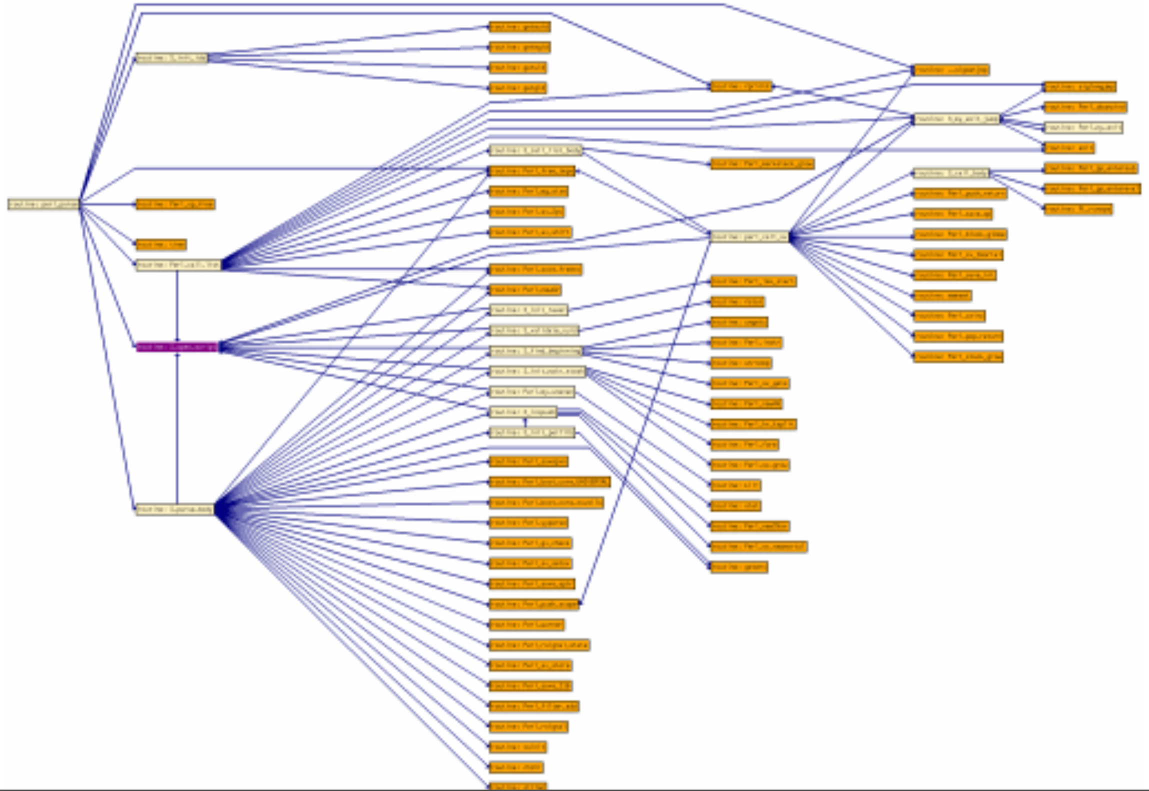
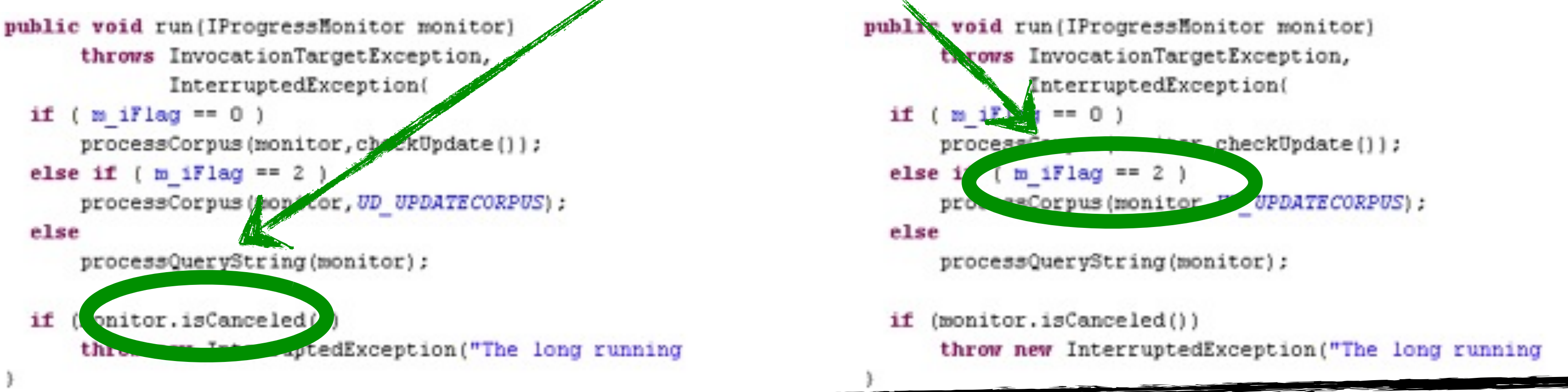


Related Work

Both relate to “corpus” processing



```
public void run(IProgressMonitor monitor)
      throws InvocationTargetException,
             InterruptedException{
  if ( m_iFlag == 0 )
      processCorpus(monitor,checkUpdate());
  else if ( m_iFlag == 2 )
      processCorpus(monitor,UD_UPDATECORPUS);
  else
      processQueryString(monitor);

  if (monitor.isCanceled())
      throw new InterruptedException("The long running
}
```

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      throws InvocationTargetException,
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Software change IA via Information Retrieval

[Canfora and Cerula MSR'06] [Hill et al. ASE'07]
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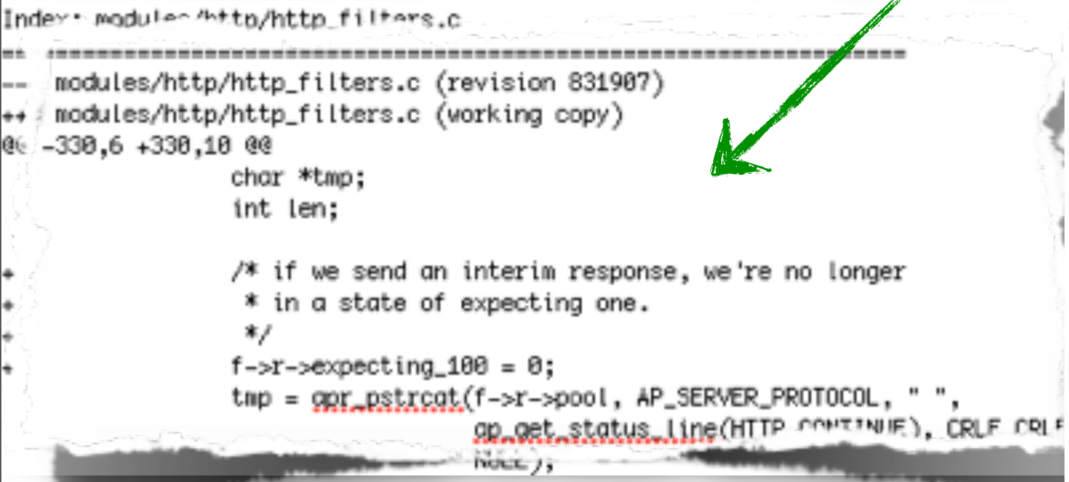
Related Work

Implement functionality related to "request body handling"



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--  modules/http/http_filters.c (revision 831907)
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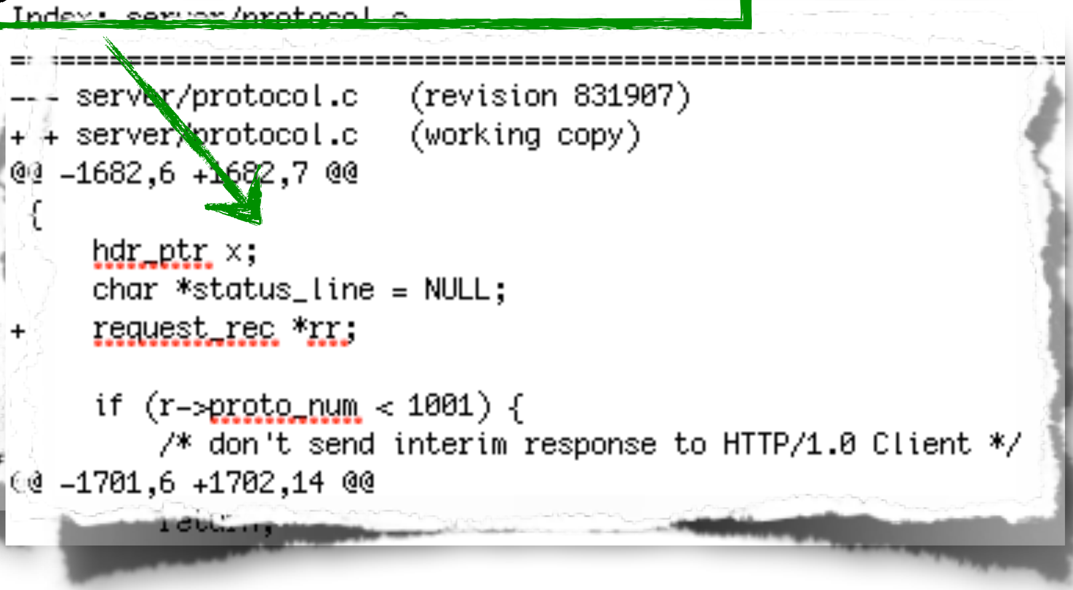
@@ -330,6 +330,10 @@
                 char *tmp;
                 int len;

+                /* if we send an interim response, we're no longer
+                 * in a state of expecting one.
+                 */
+                f->r->expecting_100 = 0;
                 tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                                   ap_get_status_line(HTTP_CONTINUE), CRLF CRL
                                   NULL);
```



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Index: server/protocol.c
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--- server/protocol.c   (revision 831907)
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         return;
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Software change IA via Mining Software Repositories

[Zimmermann et al. TSE'05] [Gall et al. ICSM'98]
[Kagdi et al. WCRE'10] [Canfora and Cerula MSR'06]

Research Goal

Develop a novel Impact Analysis (IA) approach that adapts to specific maintenance scenarios

- Information Retrieval (IR), Latent Semantic Indexing (LSI)
- Mining Software Repositories (MSR), Itemset Mining
- Run time information, execution traces

Research Goal

novel Impact Analysis (IA) approach
maintenance scenarios

nt

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•Mining S

Itemset Mining

•Run time information, executio

HOW CAN WE INTEGRATE THESE INFORMATION SOURCES FOR IA?

Scenario-Driven Approach

Default: Given a textual change request, an Information Retrieval (IR) (e.g., Latent Semantic Indexing) is used to estimate the impact set.

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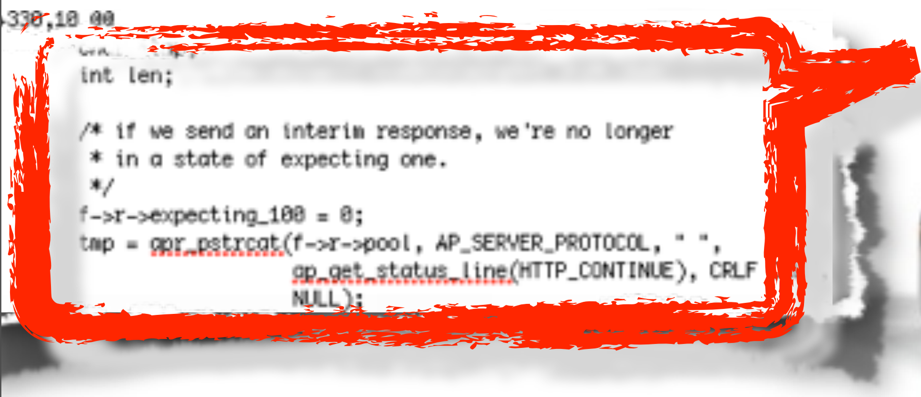
<u>Scenario 1:</u>

User provides a verified starting entity



```
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int len;

/* if we send an interim response, we're no longer
 * in a state of expecting one.
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f->r->expecting_100 = 0;
tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
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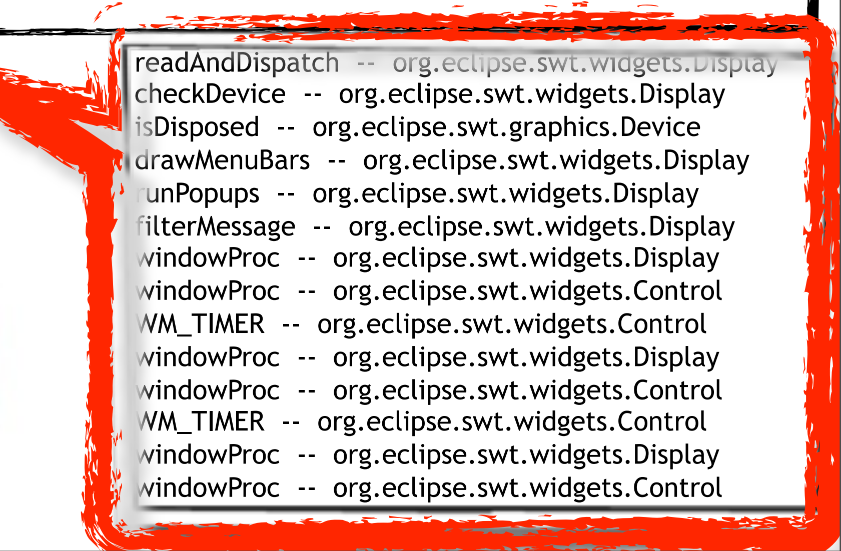
                  NULL);
```

Scenario-Driven Approach

Default: Given a textual change request, an Information Retrieval (IR) (e.g., Latent Semantic Indexing) is used to estimate the impact set.

Scenario 2:

User provides an execution trace



```
readAndDispatch  --  org.eclipse.swt.widgets.Display
checkDevice  --  org.eclipse.swt.widgets.Display
isDisposed  --  org.eclipse.swt.graphics.Device
drawMenuBars  --  org.eclipse.swt.widgets.Display
runPopups  --  org.eclipse.swt.widgets.Display
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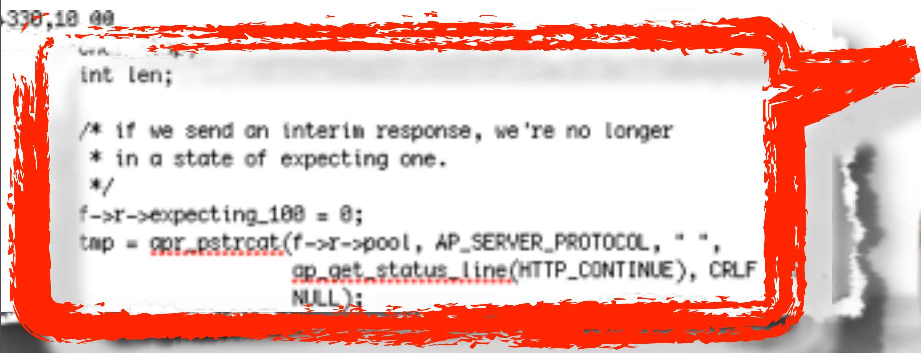
Scenario-Driven Approach

<u>Default:</u> Given a textual change request, an Information Retrieval (IR) (e.g., Latent Semantic Indexing) is used to estimate the impact set.

<u>Scenario 3:</u>

Both verified starting entity and run-time information are available



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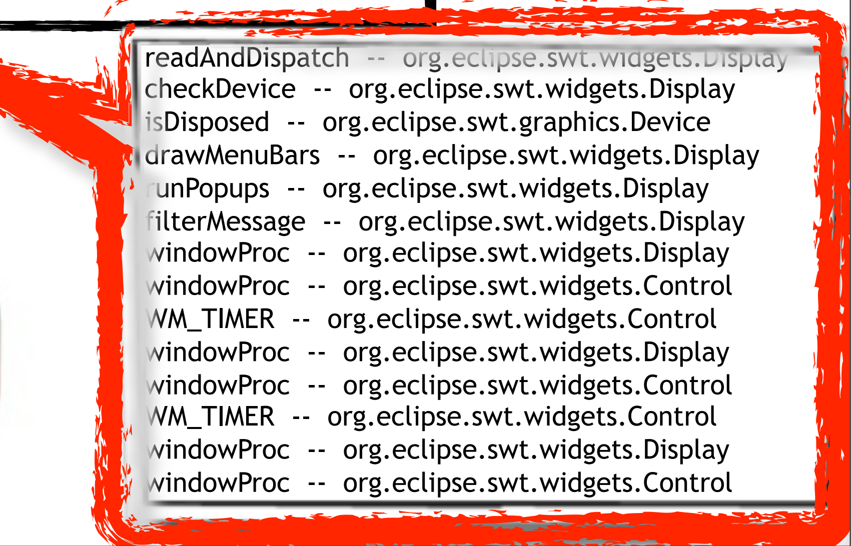

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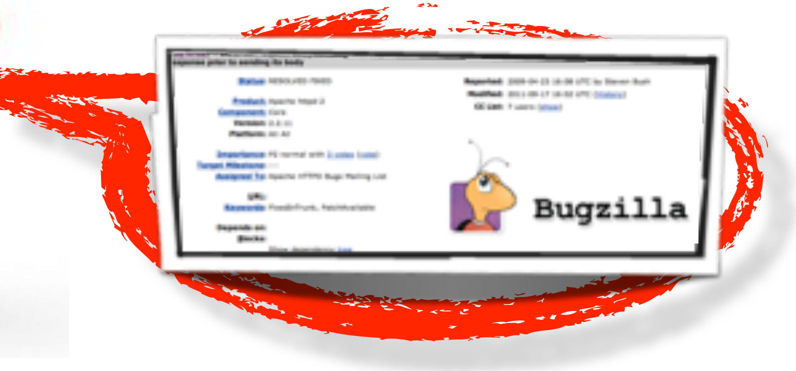
```

Approach (IR)

IR (default): Analyzing textual information via IR



[illegible] response prior to sending the body

Status: RESOLVED FIXED

Product: Apache httpd-2
Component: Core
Version: 2.2.11
Platform: All All

Importance: P2 normal with [illegible] votes (vote)
Target Milestone: ---
Assigned To: Apache HTTPD Bugs Mailing List

URL:
Keywords: FixedInTrunk, PatchAvailable

Depends on:
Blocks:
Show dependency tree

Reported: 2009-04-23 [illegible] UTC by [illegible]
Modified: 2011-09-17 [illegible] UTC (History)
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Approach (IR)

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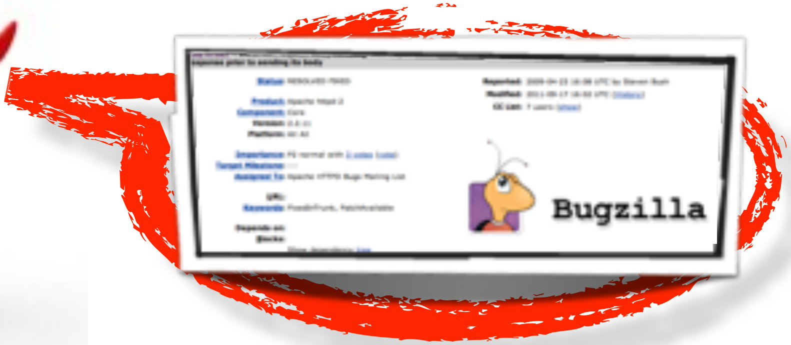

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Component: Core
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Platform: All All

Importance: P2 normal with 3 votes (vote)
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Reported: 2009-04-23 16:08 UTC by [illegible]
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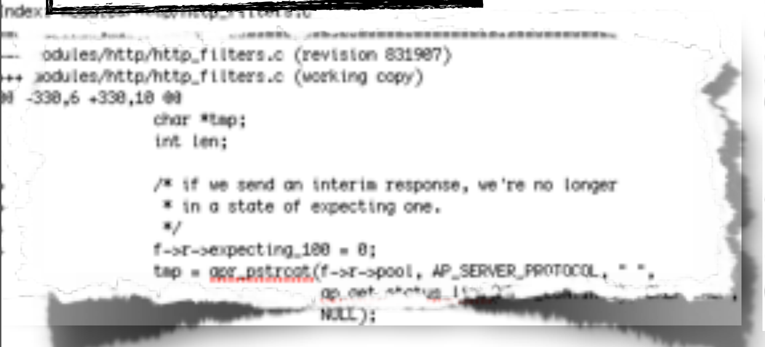
Impact Set



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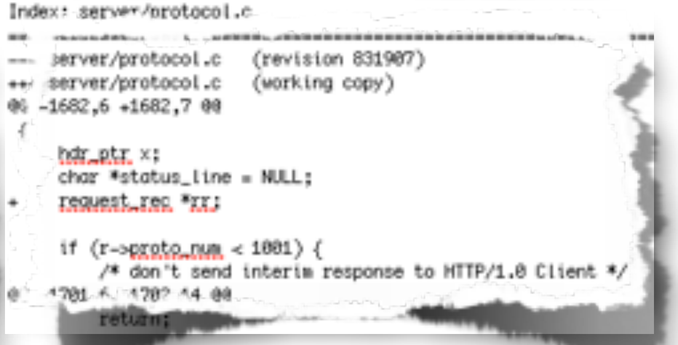
+++ modules/http/http_filters.c (working copy)
@@ -330,6 +330,10 @@
             char *tmp;
             int len;

             /* if we send an interim response, we're no longer
              * in a state of expecting one.
              */
             f->r->expecting_100 = 0;
             tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                               ap_get_status_line(100),
                               NULL);
```



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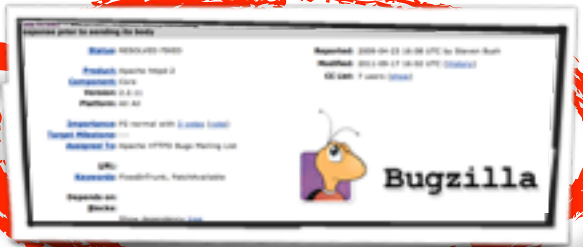
Index: server/protocol.c
===================================================================
--- server/protocol.c   (revision 831907)
+++ server/protocol.c   (working copy)
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```

Approach (IR+Dyn)

<u>IR+Dyn:</u> Analyzing textual information via IR and execution information via dynamic analysis



Status: RESOLVED FIXED

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Component: Core
Version: 2.2.11
Platform: All All

Importance: P2 normal with 2 votes (vote)
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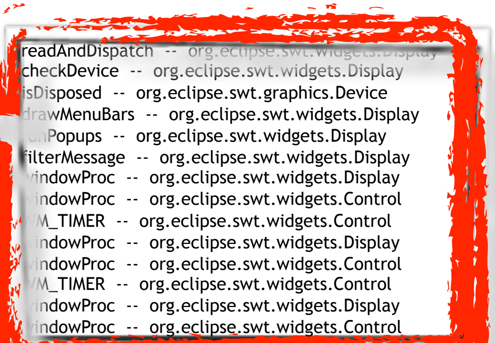

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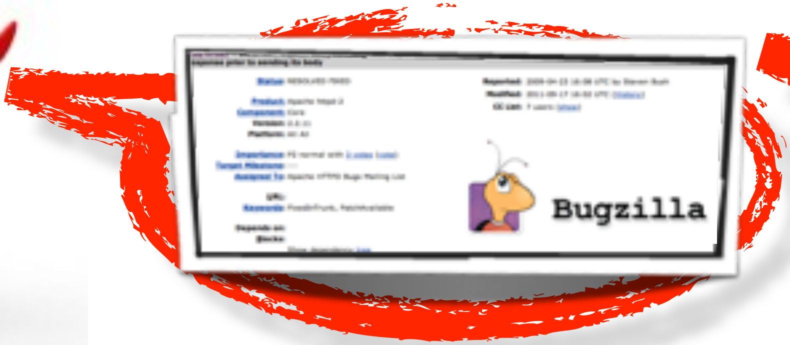
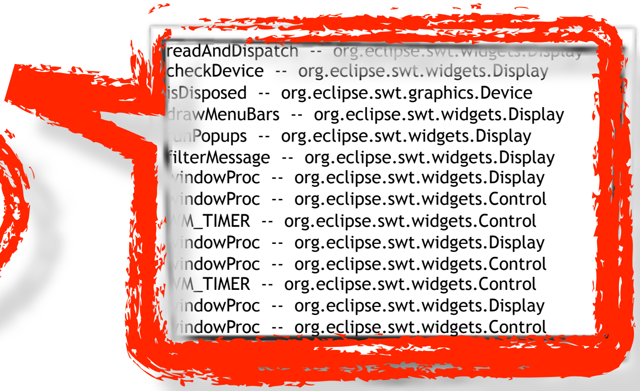
Approach (IR+Dyn)

IR+Dyn: Analyzing textual information via IR and execution information via dynamic analysis



Status: RESOLVED FIXED
Product: Apache httpd-2
Component: Core
Version: [illegible]
Platform: All All
Importance: [illegible]
Target Milestone: ---
Assigned To: Apache HTTPD Bugs Mailing List
URL:
Keywords: FixedInTrunk, PatchAvailable
Depends on:
Blocks:

Reported: [illegible]
Modified: [illegible]
CC List: [illegible]



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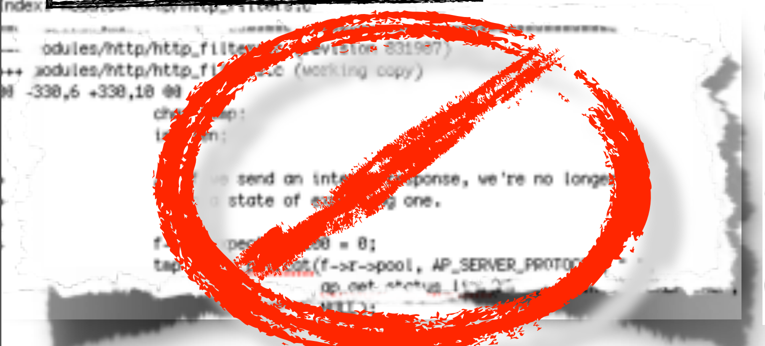
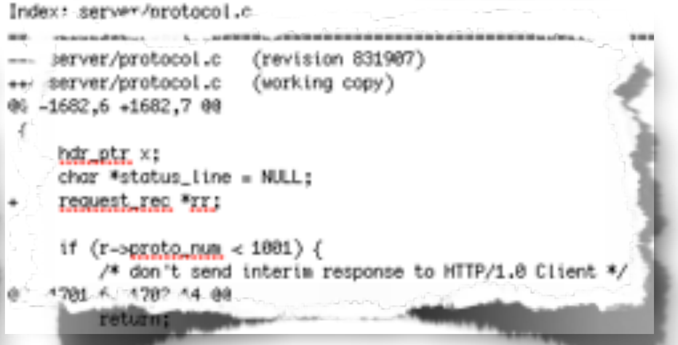
Impact Set



```
Index: [illegible]/http_filters.c
===
--- odules/http/http_filte[illegible] (revision 831987)
+++ odules/http/http_fi[illegible]c (working copy)
@@ -330,6 +330,10 @@
            ch[illegible]mp;
            i[illegible]n;

              [illegible] send an inte[illegible]sponse, we're no longe[illegible]
              [illegible] state of e[illegible]g one.

            f-[illegible]pec[illegible]00 = 0;
            tmp[illegible](f->r->pool, AP_SERVER_PROTOC[illegible]
                                   ap_get_status_li[illegible]
                                   NULL);
```



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--- server/protocol.c   (revision 831987)
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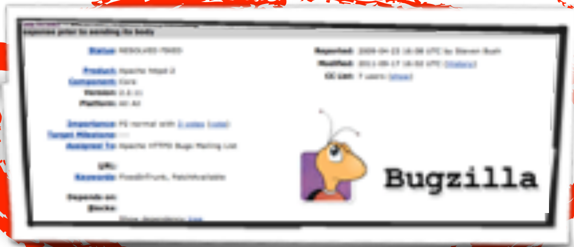
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```

Approach (IR+Dyn+Hist)

<u>IR+Dyn+Hist</u>: Analyzing textual information via IR, execution information via dynamic analysis, and history via data mining



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Platform: All All

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Target Milestone: ---
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URL:
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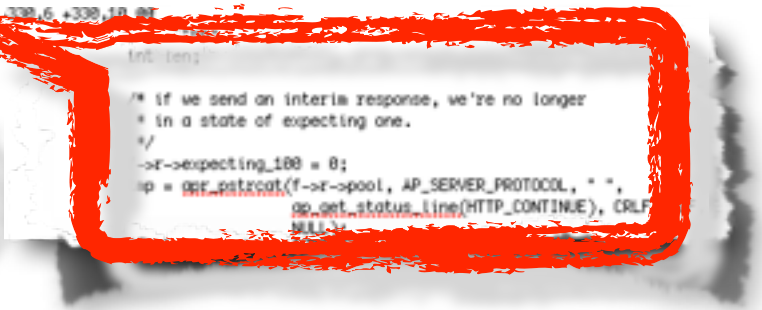
Depends on:
Blocks:

Reported: [illegible] UTC by [illegible]
Modified: [illegible] UTC (History)
CC List: 7 users (show)

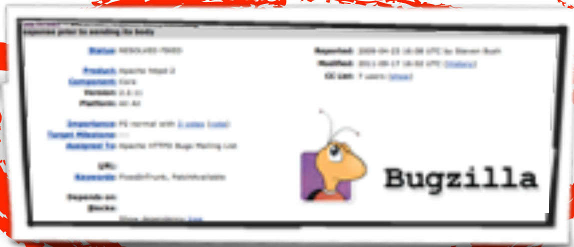


```
330,6 +330,10 @@
    int len;

/* if we send an interim response, we're no longer
 * in a state of expecting one.
 */
->r->expecting_100 = 0;
p = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                ap_get_status_line(HTTP_CONTINUE), CRLF
                NULL);
```

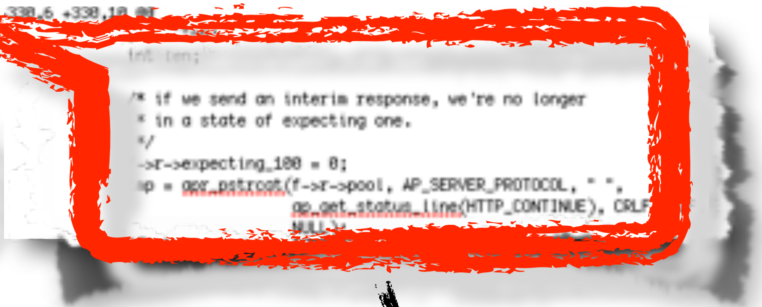
Approach (IR+Hist)

IR+Hist: Analyzing textual information via IR and history via data mining



Status: RESOLVED FIXED
Product: Apache httpd-2
Component: Core
Version: 2.2.11
Platform: All All
Importance: P2 normal with 2 votes (vote)
Target Milestone: ---
Assigned To: Apache HTTPD Bugs Mailing List
URL:
Keywords: FixedInTrunk, PatchAvailable
Depends on:
Blocks:
Show dependency tree

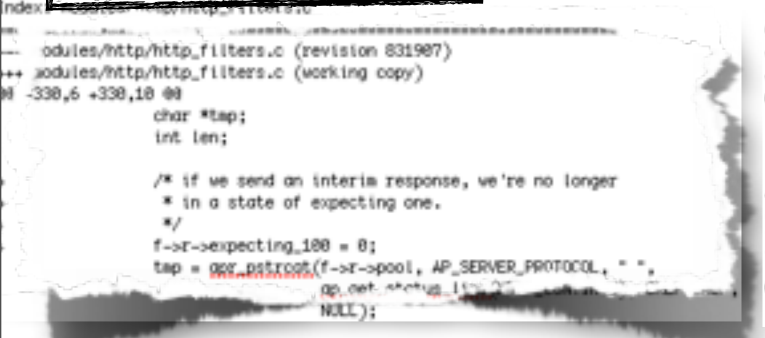
Reported: 2009-04-23 16:08 UTC by [illegible]
Modified: 2011-09-17 16:02 UTC (History)
CC List: 7 users (show)



```
330,6 +330,10 @@
        int len;

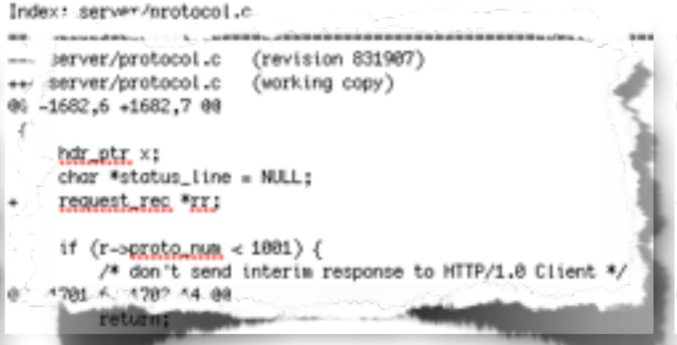
        /* if we send an interim response, we're no longer
         * in a state of expecting one.
         */
        ->r->expecting_100 = 0;
        np = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                         ap_get_status_line(HTTP_CONTINUE), CRLF
                         NULL);
```

Impact Set



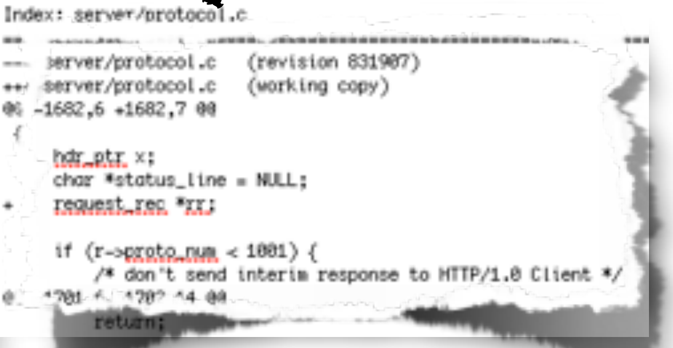
```
Index: [illegible]/http_filters.c
===================================================================
---  odules/http/http_filters.c (revision 831907)
+++ modules/http/http_filters.c (working copy)
@@ -330,6 +330,10 @@
                char *tmp;
                int len;

                /* if we send an interim response, we're no longer
                 * in a state of expecting one.
                 */
                f->r->expecting_100 = 0;
                tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                                  ap_get_status_li
                                  NULL);
```



```
Index: server/protocol.c
===================================================================
--- server/protocol.c    (revision 831907)
+++ server/protocol.c    (working copy)
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```

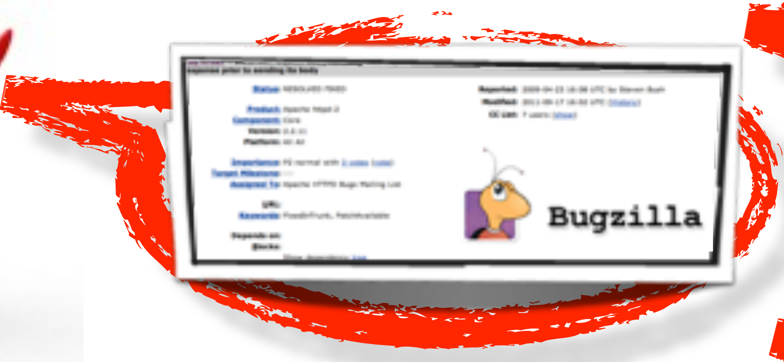


```
Index: server/protocol.c
===================================================================
--- server/protocol.c    (revision 831907)
+++ server/protocol.c    (working copy)
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```

Approach (IR+Hist)

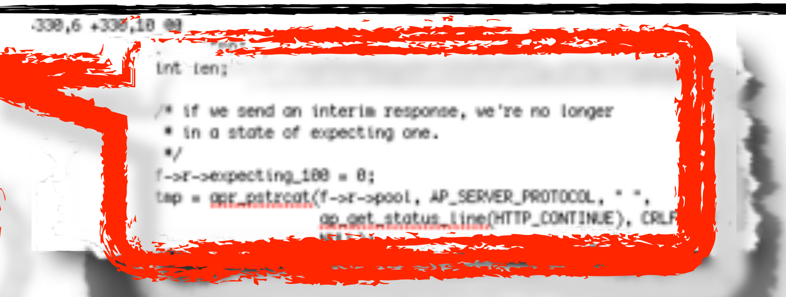
IR+Hist: Analyzing textual information via IR and history via data mining



[illegible] prior to sending the body

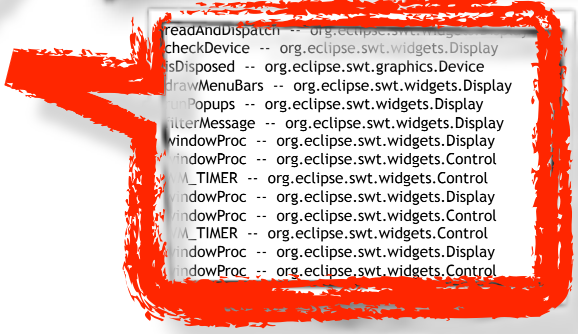
Status: [illegible]
Product: Apache httpd-2
Component: Core
Version: [illegible]
Platform: [illegible]
Importance: [illegible]
Target Milestone: ---
Assigned To: Apache HTTPD Bugs Mailing List
URL:
Keywords: [illegible]
Depends on:
Blocks:
Show dependency tree

Reported: [illegible]
Modified: [illegible] (History)
CC List: [illegible] (show)



```
-330,6 +330,10 @@
        int len;

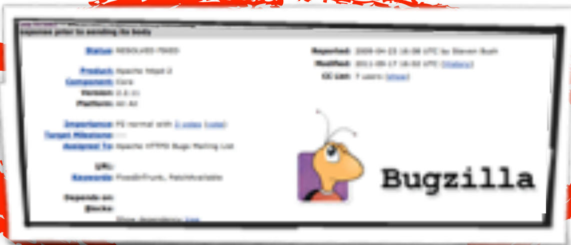
        /* if we send an interim response, we're no longer
         * in a state of expecting one.
         */
        f->r->expecting_100 = 0;
        tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                          ap_get_status_line(HTTP_CONTINUE), CRLF
```



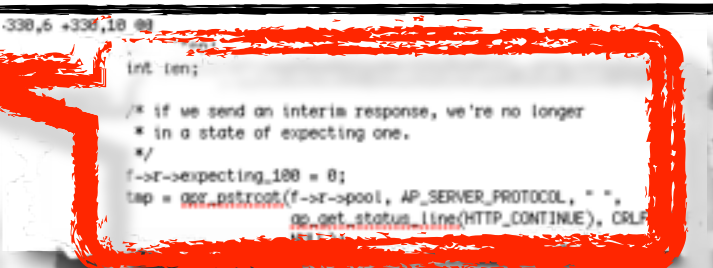
```
readAndDispatch  --  org.eclipse.swt.widgets.Display
checkDevice  --  org.eclipse.swt.widgets.Display
isDisposed  --  org.eclipse.swt.graphics.Device
drawMenuBars  --  org.eclipse.swt.widgets.Display
runPopups  --  org.eclipse.swt.widgets.Display
filterMessage  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Control
WM_TIMER  --  org.eclipse.swt.widgets.Control
windowProc  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Control
WM_TIMER  --  org.eclipse.swt.widgets.Control
windowProc  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Control
```

Approach (IR+Hist)

IR+Hist: Analyzing textual information via IR and history via data mining

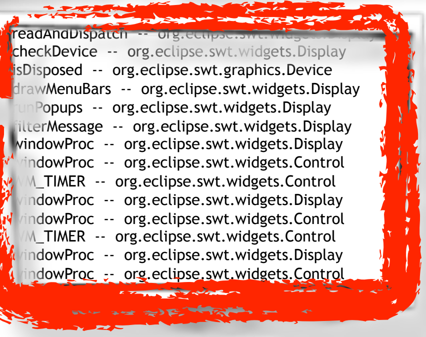


Status: RESOLVED FIXED
Product: Apache httpd-2
Component: Core
Version: 2.2.11
Platform: All All
Importance: P2 normal with 2 votes (vote)
Target Milestone: ---
Assigned To: Apache HTTPD Bugs Mailing List
URL:
Keywords: FixedInTrunk, PatchAvailable
Depends on:
Blocks:
Show dependency tree
Reported:
Modified: (history)
CC List: 7 users (show)



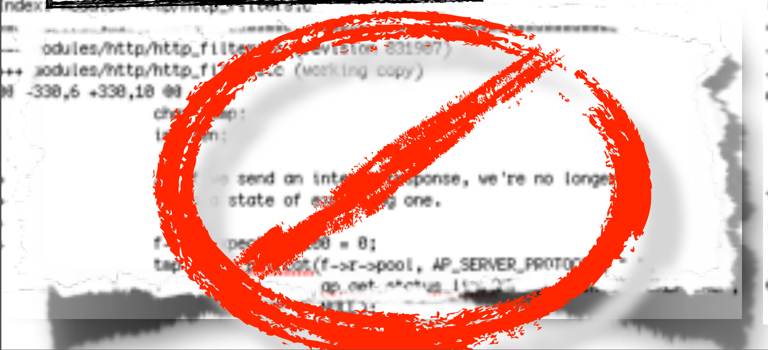
```
-330,6 +330,10 @@
    int len;

    /* if we send an interim response, we're no longer
     * in a state of expecting one.
     */
    f->r->expecting_100 = 0;
    tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                      ap_get_status_line(HTTP_CONTINUE), CRLF
```



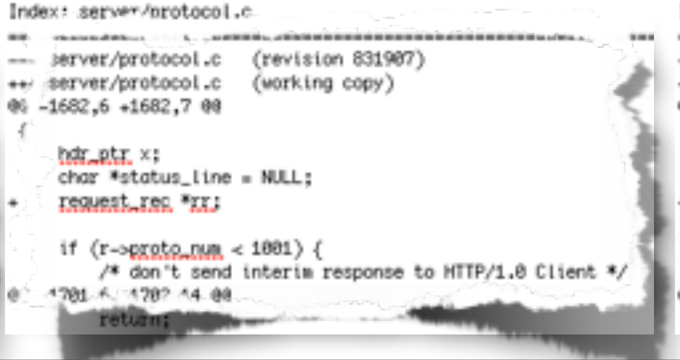
```
readAndDispatch  --  org.eclipse.swt.widgets.Display
checkDevice  --  org.eclipse.swt.widgets.Display
isDisposed  --  org.eclipse.swt.graphics.Device
drawMenuBars  --  org.eclipse.swt.widgets.Display
runPopups  --  org.eclipse.swt.widgets.Display
filterMessage  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Control
WM_TIMER  --  org.eclipse.swt.widgets.Control
windowProc  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Control
WM_TIMER  --  org.eclipse.swt.widgets.Control
windowProc  --  org.eclipse.swt.widgets.Display
windowProc  --  org.eclipse.swt.widgets.Control
```

Impact Set



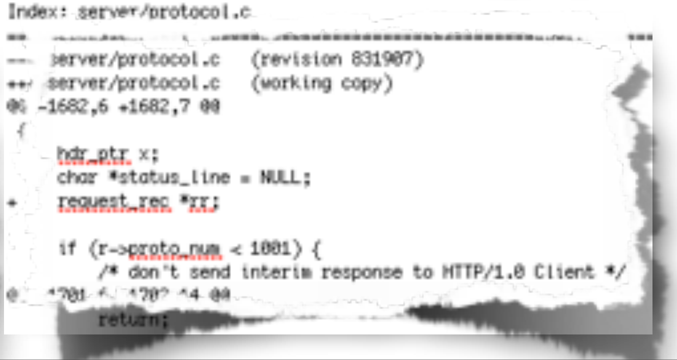
```
Index: modules/http/http_filters.c
===================================================================
--- modules/http/http_filters.c (revision 831987)
+++ modules/http/http_filters.c (working copy)
@@ -330,6 +330,10 @@
            char *tmp;
            int len;

+           /* if we send an interim response, we're no longer
+            * in a state of expecting one.
+            */
+           f->r->expecting_100 = 0;
            tmp = apr_pstrcat(f->r->pool, AP_SERVER_PROTOCOL, " ",
                              ap_get_status_line(HTTP_CONTINUE), CRLF
                              NULL);
```



```
Index: server/protocol.c
===================================================================
--- server/protocol.c   (revision 831987)
+++ server/protocol.c   (working copy)
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```



```
Index: server/protocol.c
===================================================================
--- server/protocol.c   (revision 831987)
+++ server/protocol.c   (working copy)
@@ -1682,6 +1682,7 @@
 {
     hdr_ptr x;
     char *status_line = NULL;
+    request_rec *rr;

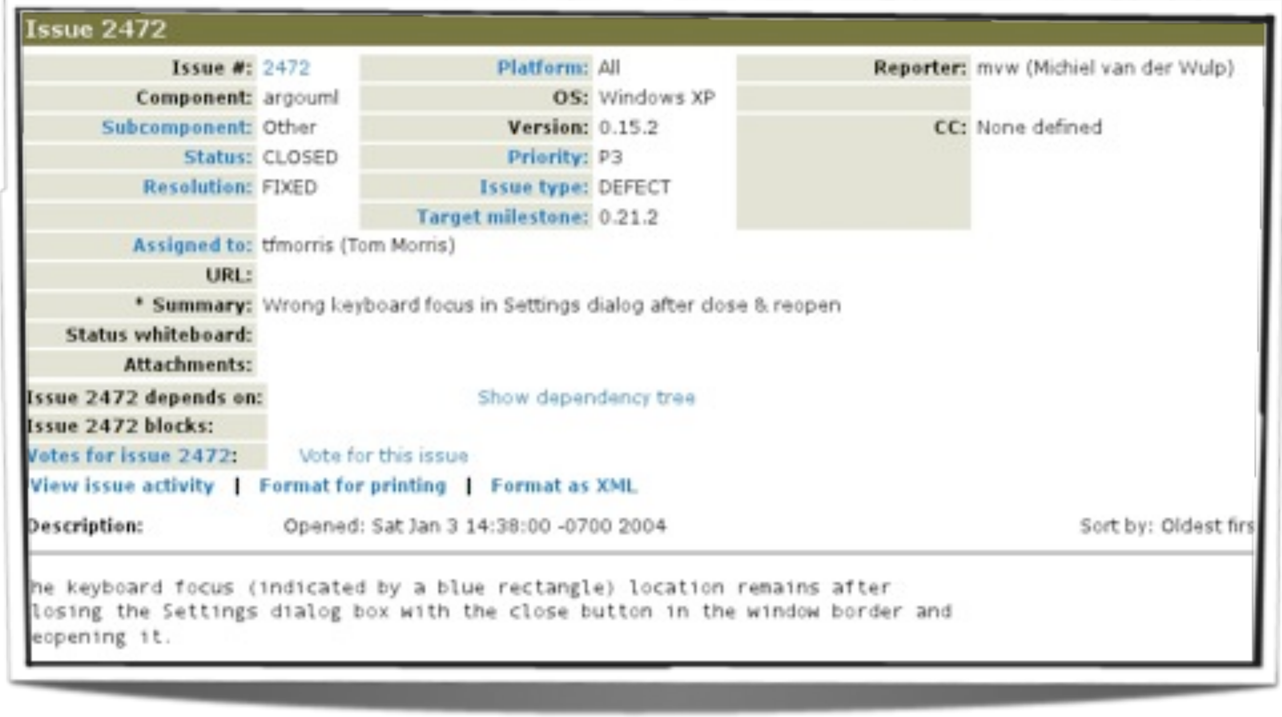
     if (r->proto_num < 1001) {
         /* don't send interim response to HTTP/1.0 Client */
@@ -1701,6 +1702,14 @@
         return;
```

Impact Analysis - Motivating Example

ArgoUML Bug #2472:

"Wrong keyboard focus in settings dialog after close & reopen [...]"

- 16 methods impacted by bug #2472



Issue 2472

Issue #:	2472	Platform:	All	Reporter:	mvw (Michiel van der Wulp)
Component:	argouml	OS:	Windows XP		
Subcomponent:	Other	Version:	0.15.2	CC:	None defined
Status:	CLOSED	Priority:	P3		
Resolution:	FIXED	Issue type:	DEFECT		
		Target milestone:	0.21.2		

Assigned to: tfmorris (Tom Morris)

URL:

* Summary: Wrong keyboard focus in Settings dialog after dose & reopen

Status whiteboard:

Attachments:

Issue 2472 depends on: Show dependency tree

Issue 2472 blocks:

Votes for issue 2472: Vote for this issue

View issue activity | Format for printing | Format as XML

Description: Opened: Sat Jan 3 14:38:00 -0700 2004 Sort by: Oldest firs

```
he keyboard focus (indicated by a blue rectangle) location remains after
losing the Settings dialog box with the close button in the window border and
eopening it.
```

- **IR (default):**

  2,16,30,...

- **IR+Dyn**

  1,3,5,7,11,12,14,29,...

Impact Analysis - Case Study

Four open source software systems, namely ArgoUML, JabRef, jEdit and muCommander

Commits in the version history used as ground truth, i.e., actual impact sets

Widely used metrics precision (false positives), recall (false negatives), and f-measure (combination of precision and recall) used for accuracy measure

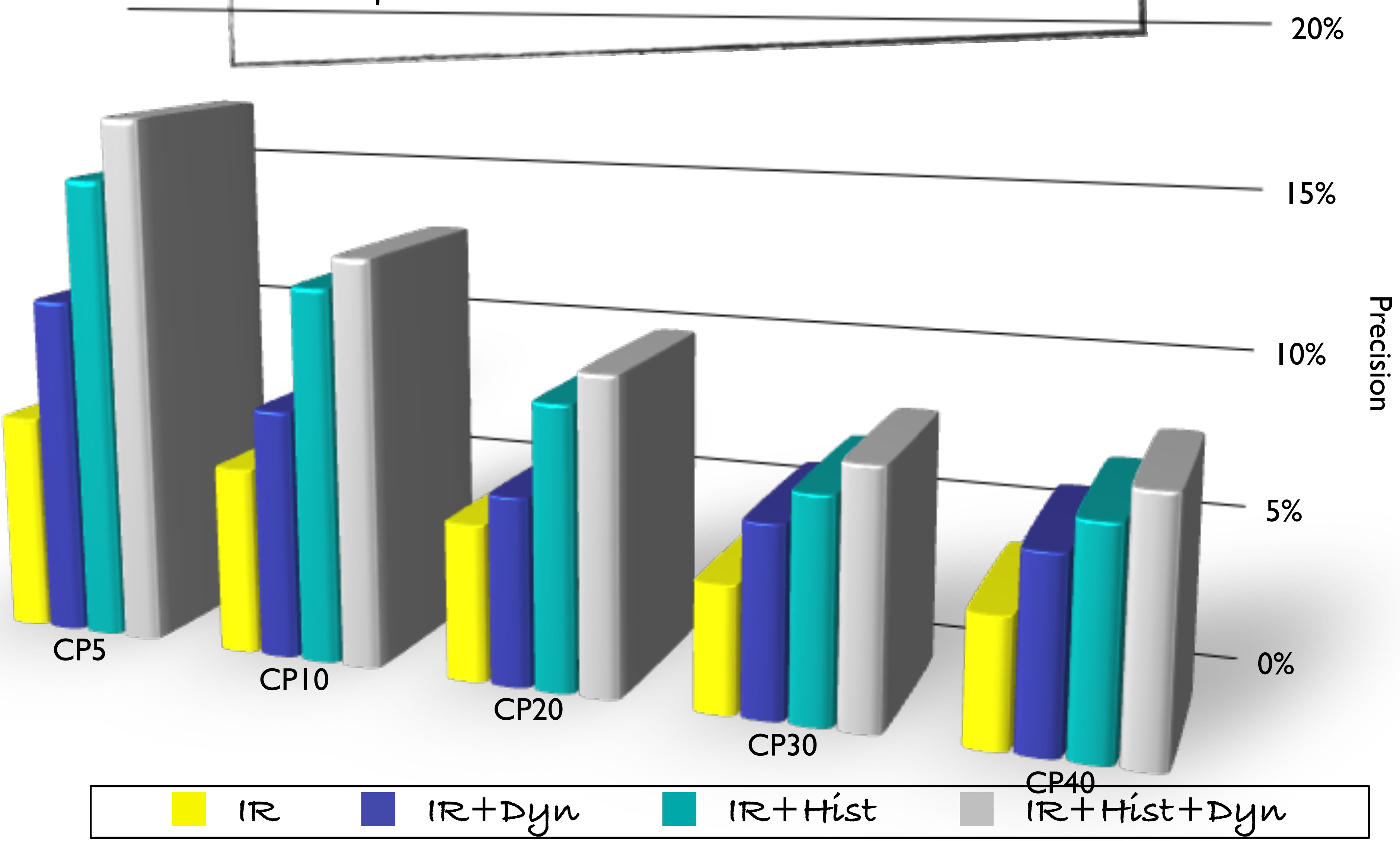
System	Version	LOC	Files	Methods	Terms
ArgoUML	0.22	148K	503	6K	4K
JabRef	2.6	74K	1,439	11K	5K
jEdit	4.3	103K	1,069	8K	4K
muCommander	0.8.5	76K	577	4K	5K

Impact Analysis - Research Question

Does providing more information improve the accuracy of IA when compared to the default approach?

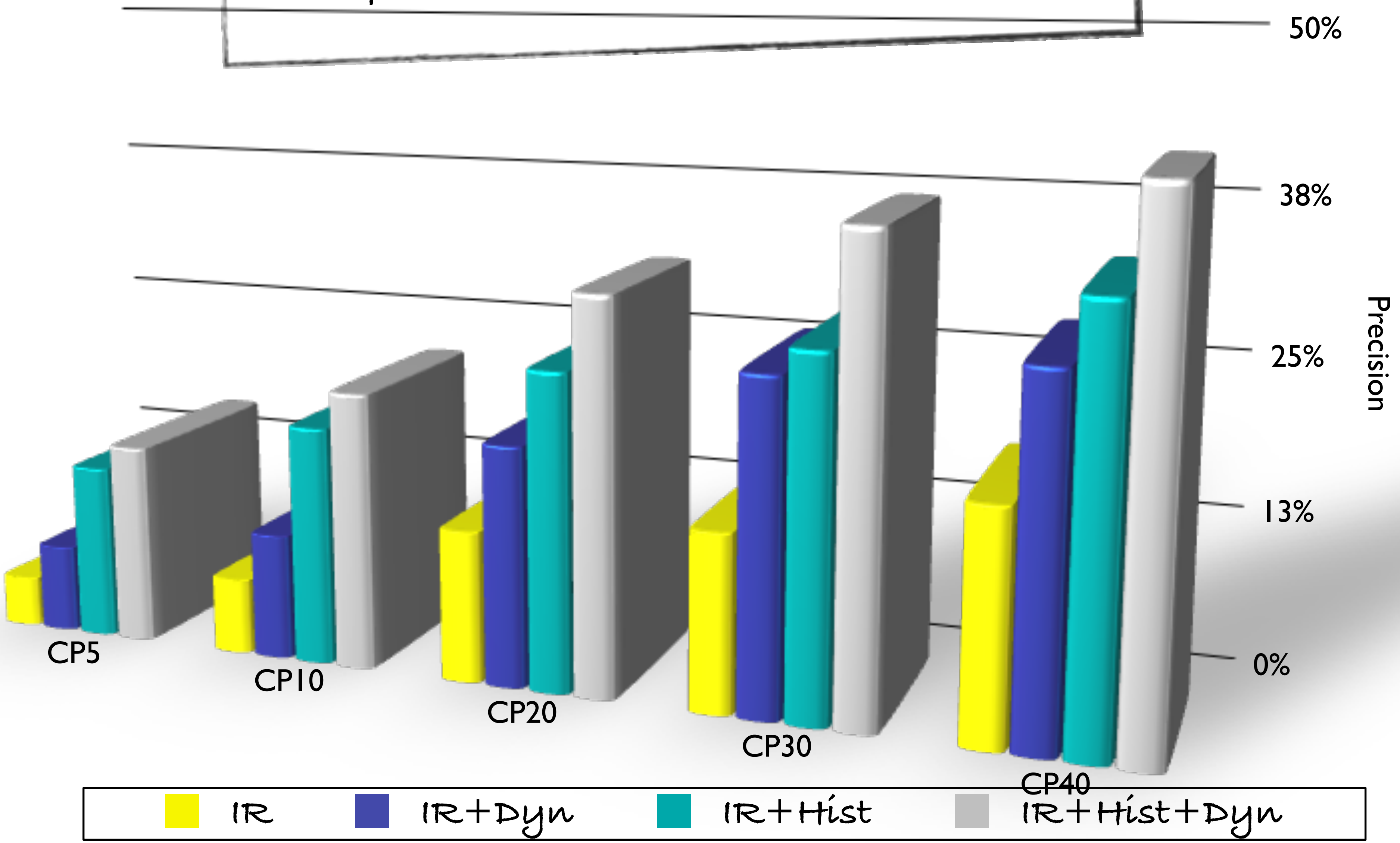
Impact Analysis - Main Results

Is it possible to improve the accuracy?



Impact Analysis - Main Results

Is it possible to improve the accuracy?



Impact Analysis - Main Results

The best results are obtained in scenarios where both a verified starting entities and execution information are available.

Recall improvements of up to 41% over the default approach and up to 17% over the evolutionary technique in iBatis

Impact Analysis - Main Results

The best results are obtained in scenarios verified starting entities and are available.

ARE OUR RESULTS STATISTICALLY SIGNIFICANT?

Recall imp default approach and up technique in iBatis

Impact Analysis - Statistical Test

Does providing more information significantly improve results of impact analysis compared to using the default approach?

Impact Analysis - Results of Wilcoxon Signed-Rank Test

System	$H_{0\ P1}$	$H_{0\ R1}$	$H_{0\ P2}$	$H_{0\ R2}$	$H_{0\ P3}$	$H_{0\ R3}$
ArgoUML	$\underline{< 0.0001}$	$\underline{< 0.0001}$	$\underline{< 0.0001}$	$\underline{< 0.0001}$	$\underline{< 0.0001}$	$\underline{< 0.0001}$
JabRef	0.266	0.324	0.381	$\underline{< 0.0001}$	0.091	$\underline{< 0.0001}$
jEdit	$\underline{< 0.0001}$	$\underline{< 0.0001}$	0.068	$\underline{< 0.0001}$	$\underline{< 0.0001}$	$\underline{< 0.0001}$
muCommander	$\underline{< 0.0001}$	$\underline{< 0.0001}$	0.425	$\underline{< 0.0001}$	$\underline{< 0.0001}$	$\underline{< 0.0001}$

$H_{0\ P1}$: IR+Dyn does not significantly improve precision (compared to IR)
$H_{0\ R1}$: IR+Dyn does not significantly improve recall (compared to IR)
$H_{0\ P2}$: IR+Hist does not significantly improve precision (compared to IR)
$H_{0\ R2}$: IR+Hist does not significantly improve recall (compared to IR)
$H_{0\ P3}$: IR+Dyn+Hist does not significantly improve precision (compared to IR)
$H_{0\ R3}$: IR+Dyn+Hist does not significantly improve recall (compared to IR)

Impact Analysis - Results of Wilcoxon Signed-Rank Test

	[illegible]	$H_{0\ R1}$	$H_{0\ P2}$	$H_{0\ R2}$	$H_{0\ P3}$	$H_{0\ R3}$
[illegible]	[illegible]	[illegible]	[illegible]	< 0.0001	< 0.0001	< 0.0001
JabRef	[illegible]	[illegible]	[illegible]	[illegible]	0.091	< 0.0001
jEdit	< 0.0001	[illegible]	[illegible]	[illegible]	[illegible]	< 0.0001
muCommander	< 0.0001	< 0.0001	[illegible]	[illegible]	[illegible]	[illegible]

RESULTS ARE STATISTICALLY SIGNIFICANT!

$H_{0\ P1}$: IR+Dyn does not significantly improve precision (compared to IR)

$H_{0\ R1}$: IR+Dyn does not significantly improve recall (compared to IR)

$H_{0\ P2}$: IR+Hist does not significantly improve precision (compared to IR)

$H_{0\ R2}$: IR+Hist does not significantly improve recall (compared to IR)

$H_{0\ P3}$: IR+Dyn+Hist does not significantly improve precision (compared to IR)

$H_{0\ R3}$: IR+Dyn+Hist does not significantly improve recall (compared to IR)

Threats to Validity

Commits used as gold standard for accuracy computation

- Not all the entities in a commit maybe related to a single change request
- All the entities related to a single change request maybe present in a single commit
- Developer established actual change-sets

Quality of dynamic traces obtained for change request

Statistically significant results for the four open source Java systems may not generalize

Conclusion

Scenario-driven combination of IR, dynamic analysis and MSR techniques for IA

Recall improvements of up to 41% over the default approach

Precision improvement up to 17% over the default approach

Thank You

SEMERU @ William and Mary

http://www.cs.wm.edu/semeru