Uncovering SAP vulnerabilities: Reversing and breaking the Diag protocol

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BruCon – September 2012

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Agenda

- Introduction
- Motivation and related work
- SAP Netweaver architecture and protocols layout
- Dissecting and understanding the Diag protocol
- Results and findings
- Defenses and countermeasures
- Conclusion and future work

Introduction

Introduction

- Leader business software provider
- Sensitive enterprise business processes runs on SAP systems

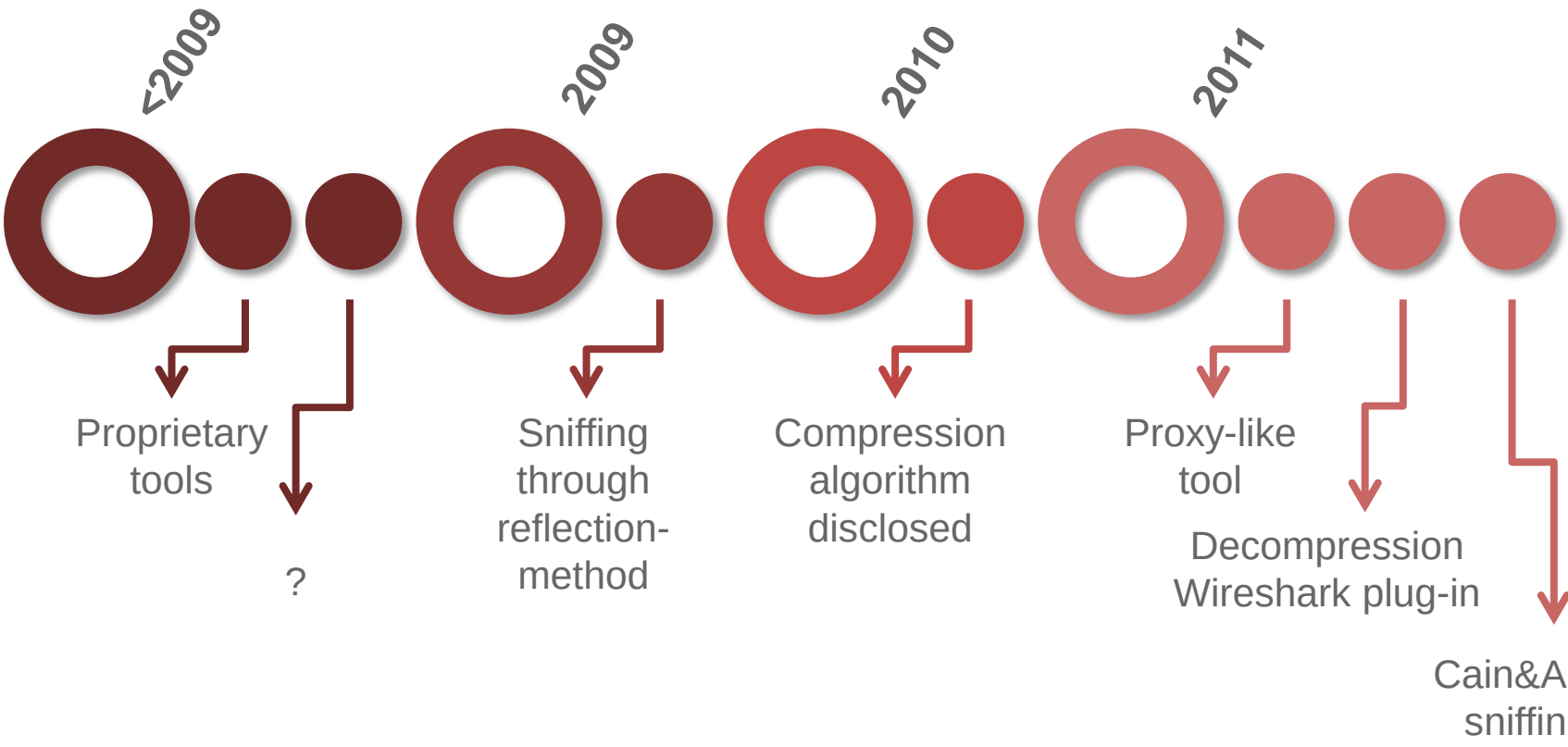
- SAP security became a hot topic
- Some components still not well covered
- Proprietary protocols used at different components

Introduction

- Dynamic Information and Action Gateway (Diag) protocol (aka “SAP GUI protocol”)
- Link between presentation layer (SAP GUI) and application layer (SAP Netweaver)
- Present in every SAP NW ABAP AS
- Compressed but unencrypted by default
- Optional encryption using an additional component (SNC)
- TCP ports 3200 to 3299

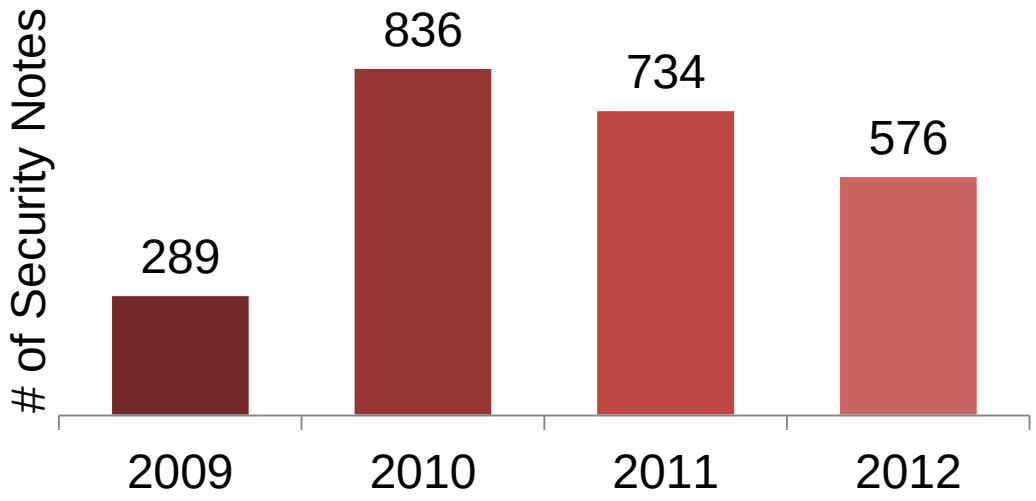
Motivation and related work

Previous work on Diag protocol



Motivation

- Previous work mostly focused on decompression
- Protocol inner workings remains unknown
- No practical tool for penetration testing
- Relevant protocol in every NW installation



Only 2 out of ~2400 security fixes published by SAP since 2009 affected components related to Diag

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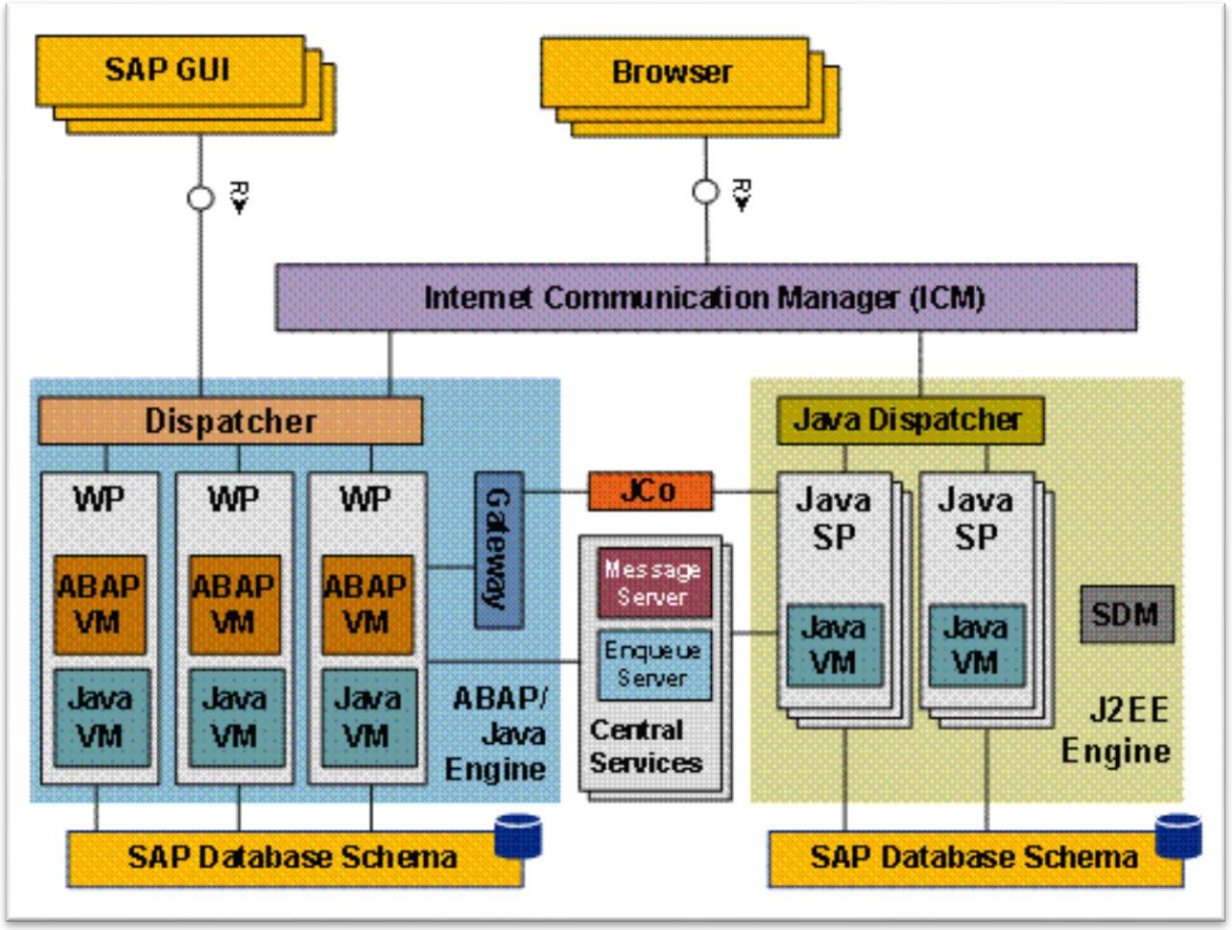
SAP Netweaver architecture and protocols layout

SAP Netweaver architecture

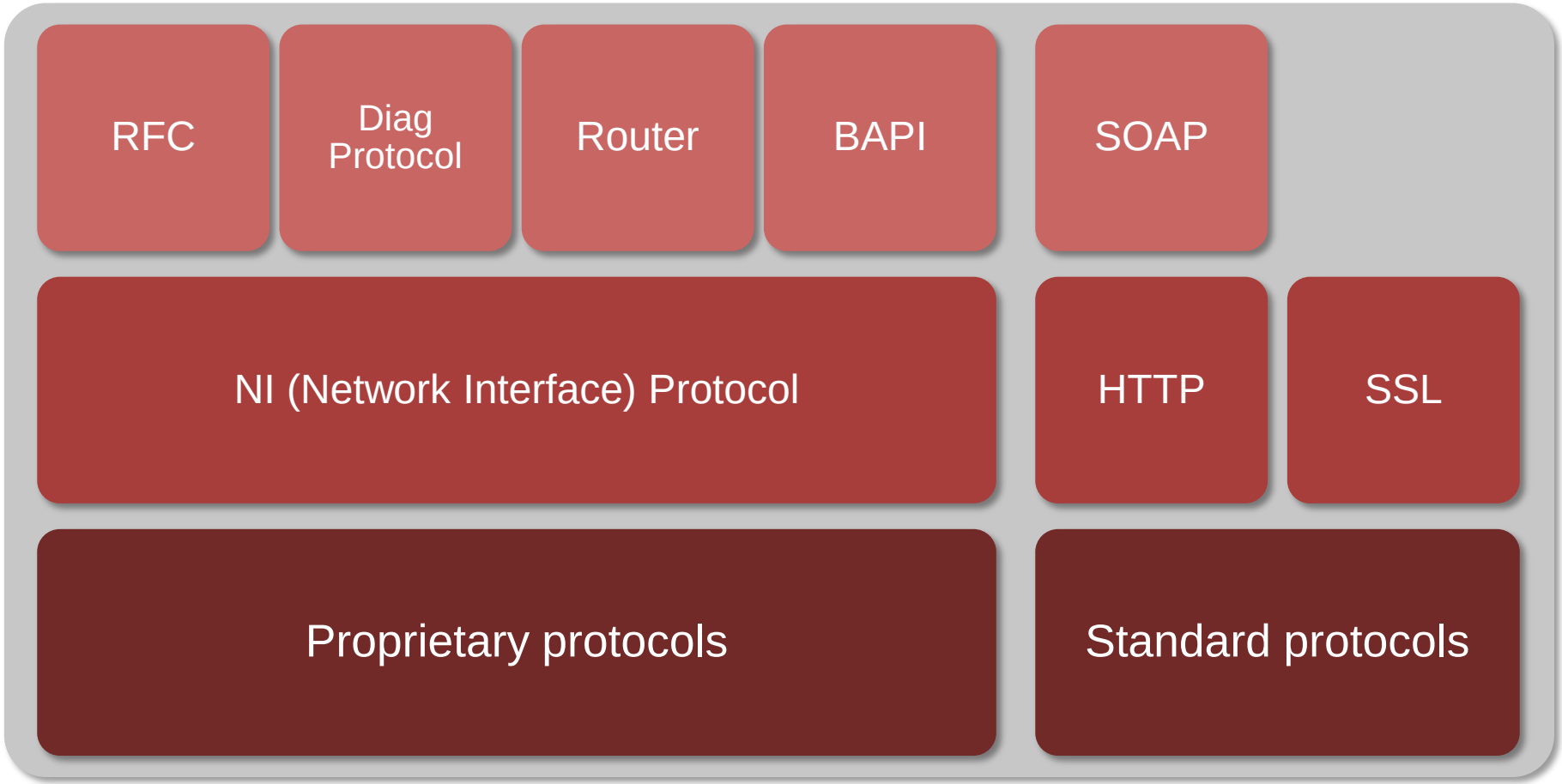


http://help.sap.com/saphelp_nw70/helpdata/en/84/54953fc405330ee10000000a114084/frameset.htm

Relevant concepts and components

- ABAP
  - SAP's programming language
- Dispatcher and work processes (wp)
  - **Dispatcher**: distribute user requests across wp
  - **Work processes**: handles specific tasks
    - Types: **dialog**, spool, update, background, lock
- Dialog processing
  - Programming method used by ABAP
  - Separates business programs in ***screens*** and ***dialog steps***

SAP Protocols layout



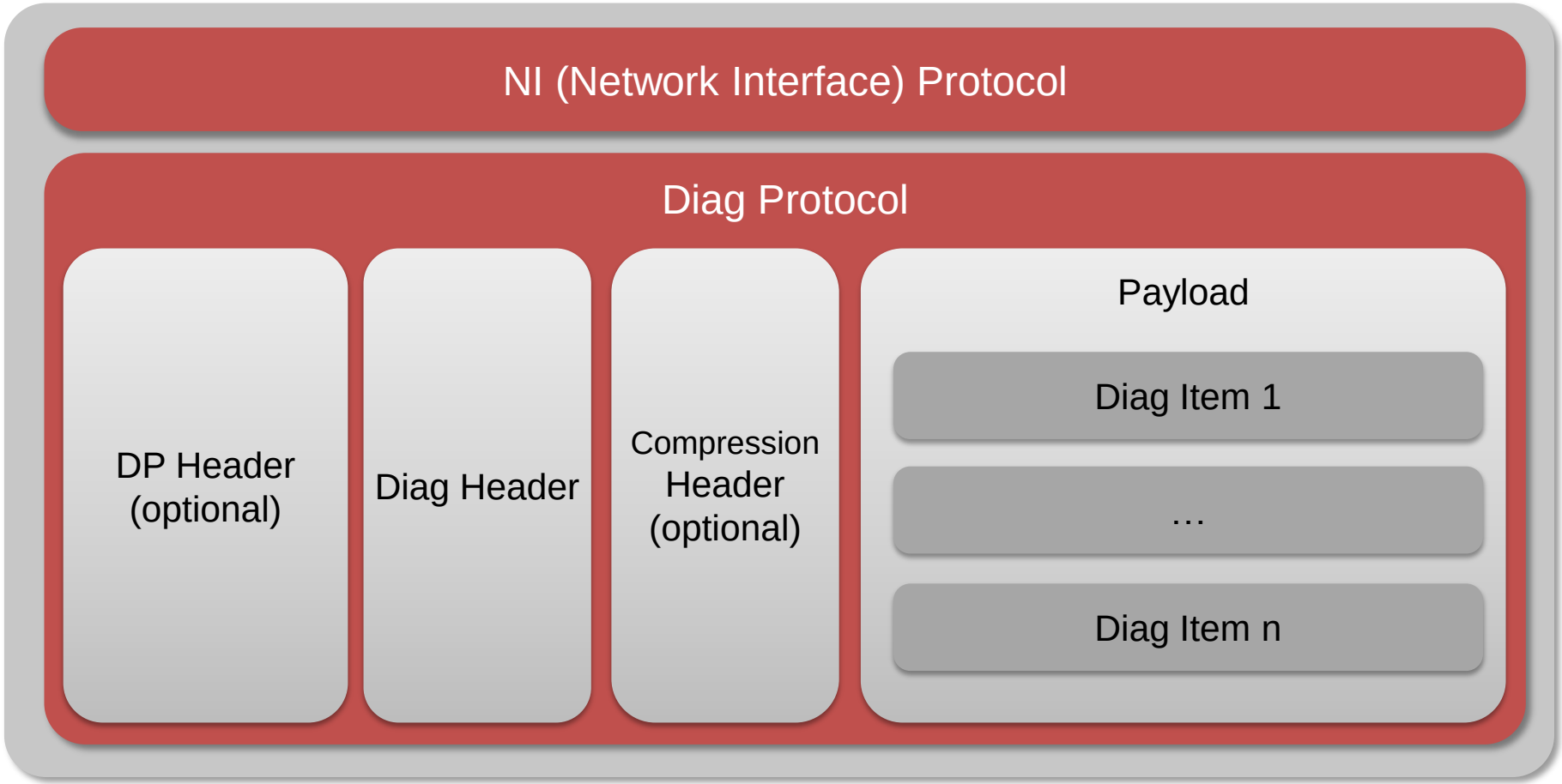
Dissecting and understanding the Diag protocol

Dissecting and understanding the Diag protocol

Approach

- ‘Black-box’
- Not reverse engineering of binaries
- Enable system/developer traces (GUI/app server)
- Analyze network and application traces
- Learn by interacting with the components (GUI/app server)
- Continuous improvement of test tools based on gained knowledge

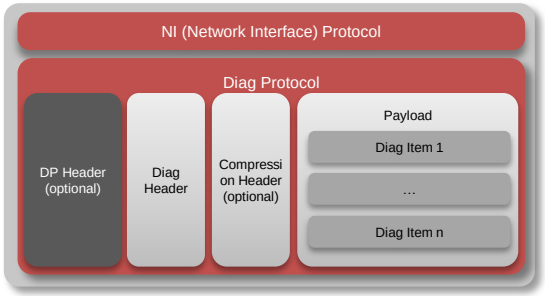
Dissecting and understanding the Diag protocol



Dissecting and understanding the Diag protocol

Initialization

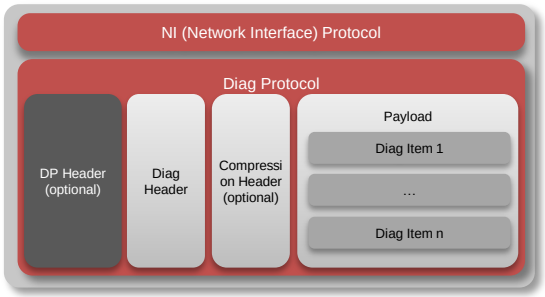
- Identified only two relevant protocol states:
  - Not initialized
  - Initialized
    - User's context assigned in shared memory
- Started by GUI application
- Only first packet
- Always uncompressed



Dissecting and understanding the Diag protocol

DP Header

- 200 bytes length
- Two different semantics
  - **IPC (inter process communication)**
    - Used in communications between dispatcher and work processes
    - Synchronization and status
  - **Network**
    - Most fields filled with default values
    - Relevant fields:
      - Terminal name, Length
- Only present during initialization (first packet)



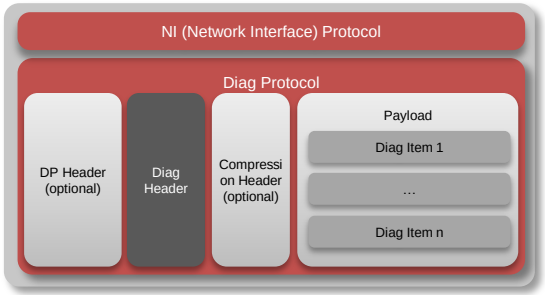
Dissecting and understanding the Diag protocol

Diag Header

Compression enabled/disabled, encryption using SNC

0	1	2	3	4	5	6	7
Mode	Comm Flag	Mode Stat	Error Flag	Msg type	Msg Info	Msg RC	Comp Flag

Identifies different sessions using the same channel



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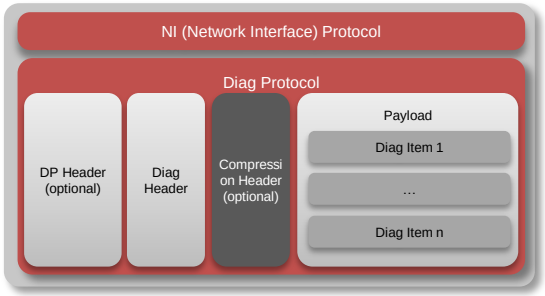
Dissecting and understanding the Diag protocol

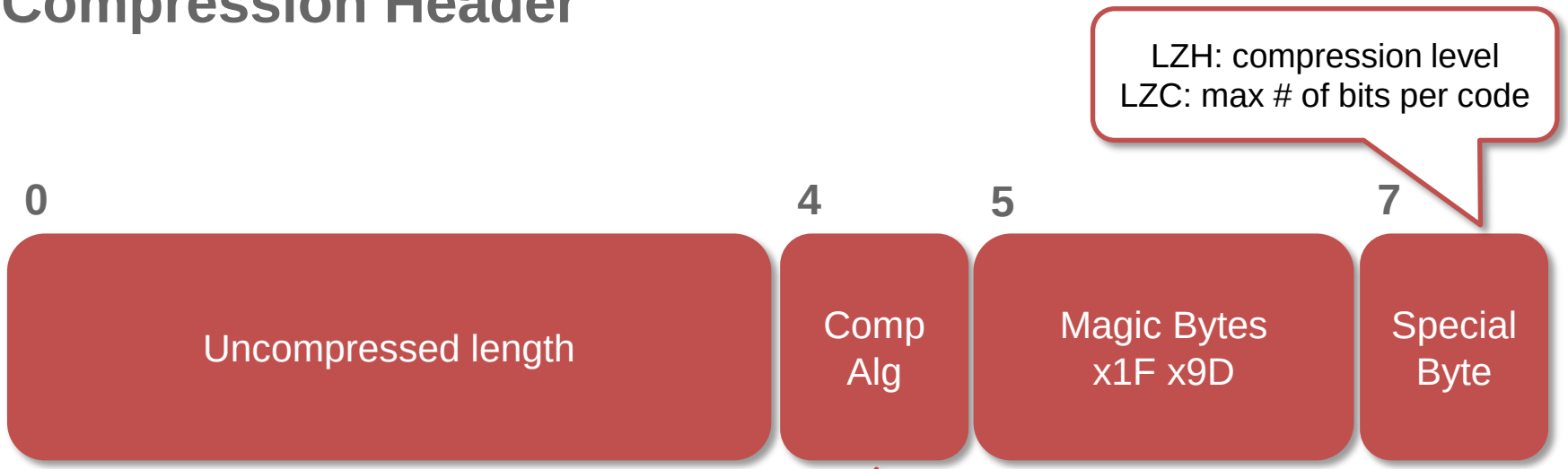
Compression

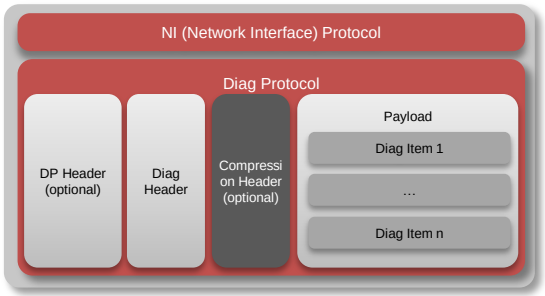
- Enabled by default
- Uses two variants of *Lempel-Ziv Adaptive Compression Algorithm*
  - *LZH* (Lempel-Ziv-Huffman) LZ77
  - *LZC* (Lempel-Ziv-Welch-Thomas) LZ78
- Same implementation as *SAP's MaxDB* open source project
- Can be disabled in GUI by setting *TDW_NOCOMPRESS* environment variable



Dissecting and understanding the Diag protocol

Compression Header





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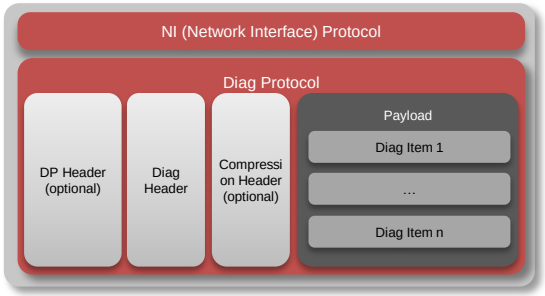
Dissecting and understanding the Diag protocol

Payload

SES	Fixed length (16 bytes)	Session information
ICO	Fixed length (20 bytes)	Icon information
TIT	Fixed length (3 bytes)	Title information
DiagMessage	Fixed length (76 bytes)	Old Diag message
OKC	(? Bytes)	
CHL	Fixed length (22 bytes)	
SBA	Fixed length (9 bytes)	List items
EOM	Fixed length (0 bytes)	End of message
APPL/APPL4	Variable length	
DIAG_XMLBlob	Variable length	XML Blob
SBA2	Fixed length (36 bytes)	List items



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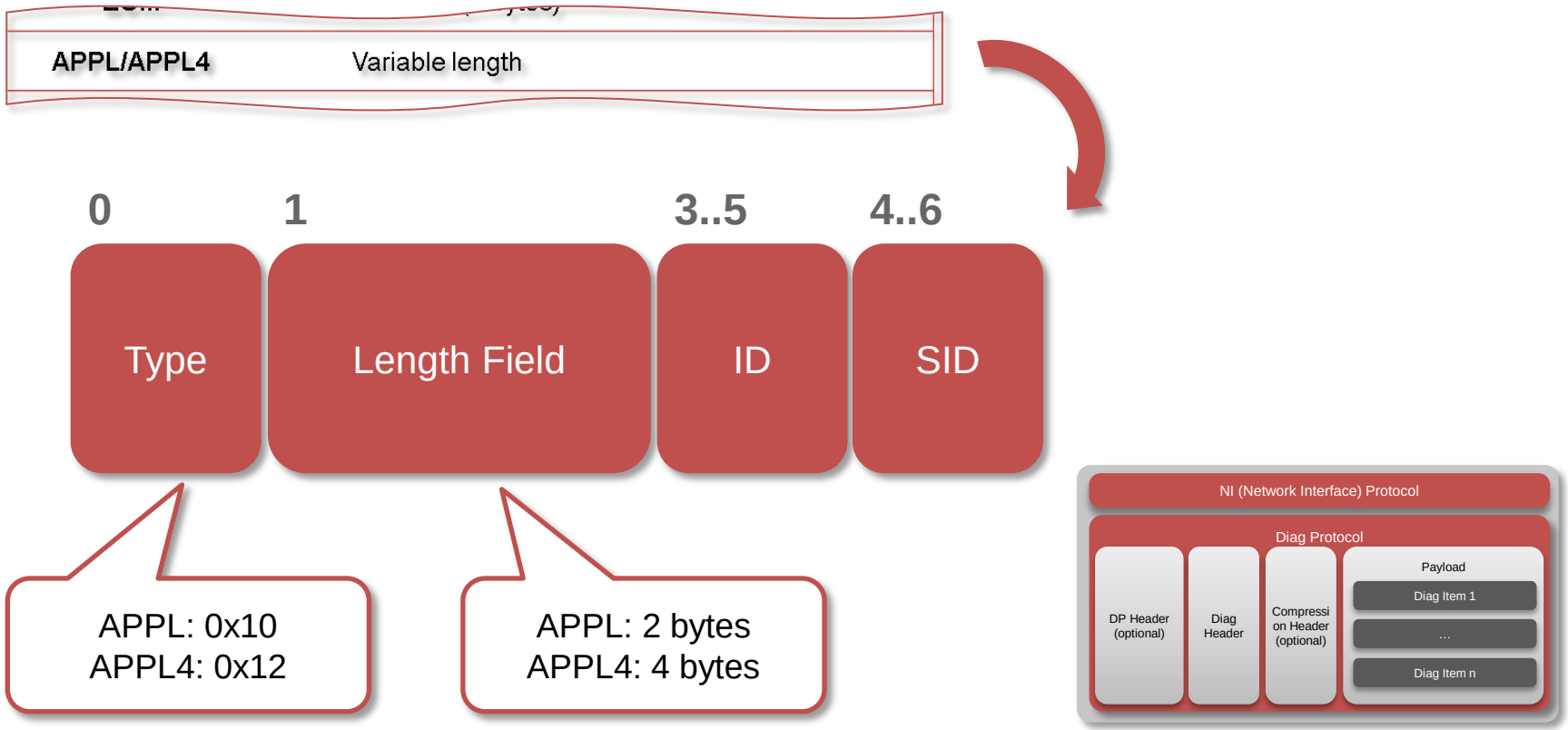
Dissecting and understanding the Diag protocol

APPL/APPL4 items



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Diag protocol security highlights

Protocol version

- APPL item included in payload during initialization
- Can disable compression using version number “200”

Authentication

- Performed as a regular dialog step
- Set user’s context on work processes shared memory

Embedded RFC calls

- APPL item that carries RFC calls in both directions
- Server doesn’t accept RFC calls until authenticated

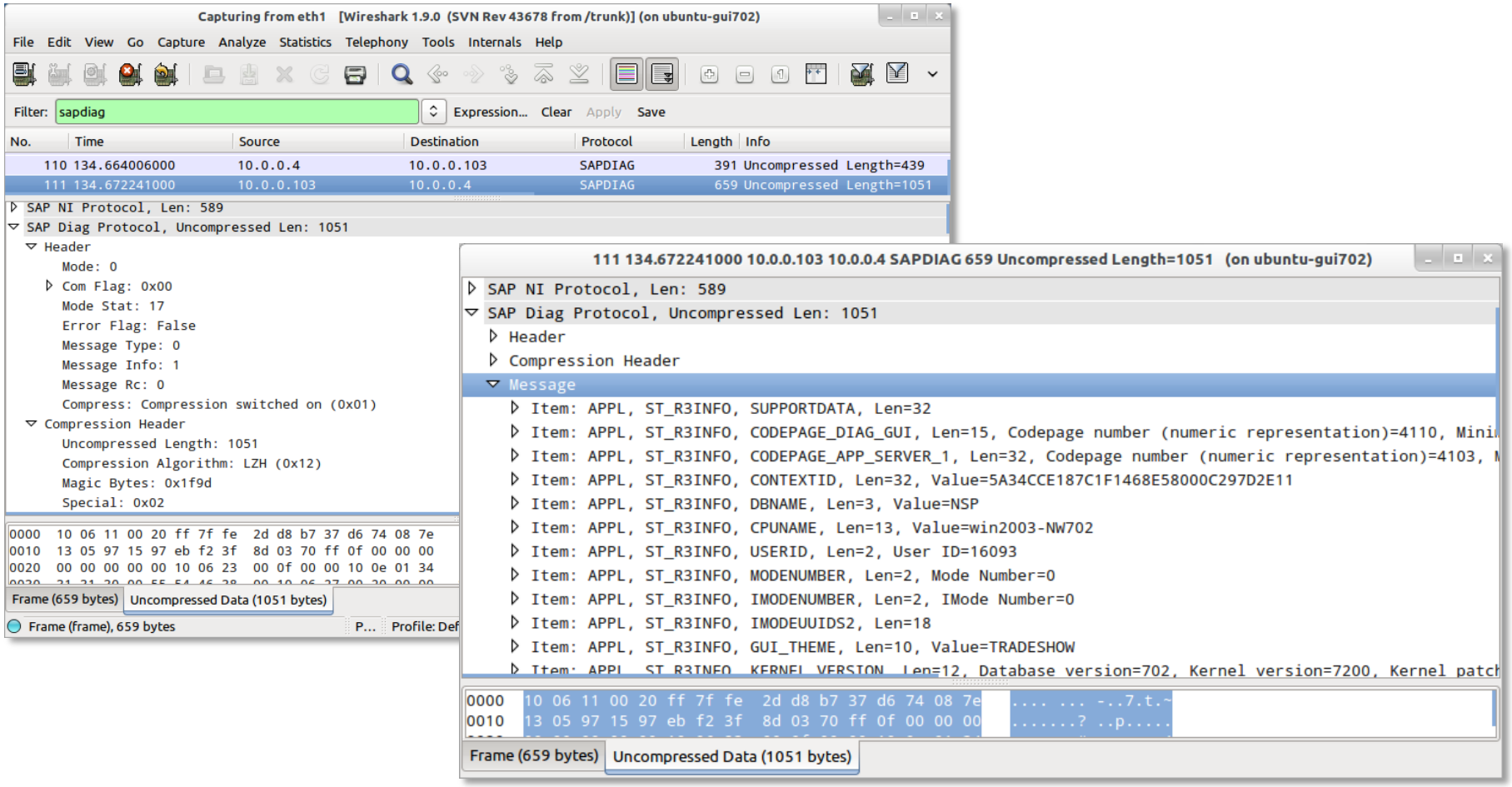
Results and findings

Packet dissection – SAP plugin for Wireshark

- Wireshark plug-in written in C/C++
  - NI Protocol dissector
    - TCP reassembling
  - Router Protocol dissector
    - Basic support
  - Diag protocol dissector
    - Decompression
    - DP header / Diag Header / Compression Header
    - Item ID/SID identification and dissection of relevant items
    - Call RFC dissector for embedded calls
  - RFC protocol dissector
    - Basic coverage of relevant parts

http://corelabs.coresecurity.com/index.php?module=Wiki&action=view&type=tool&name=SAP_Dissection_plugin_for_Wireshark

Packet dissection – SAP plugin for Wireshark



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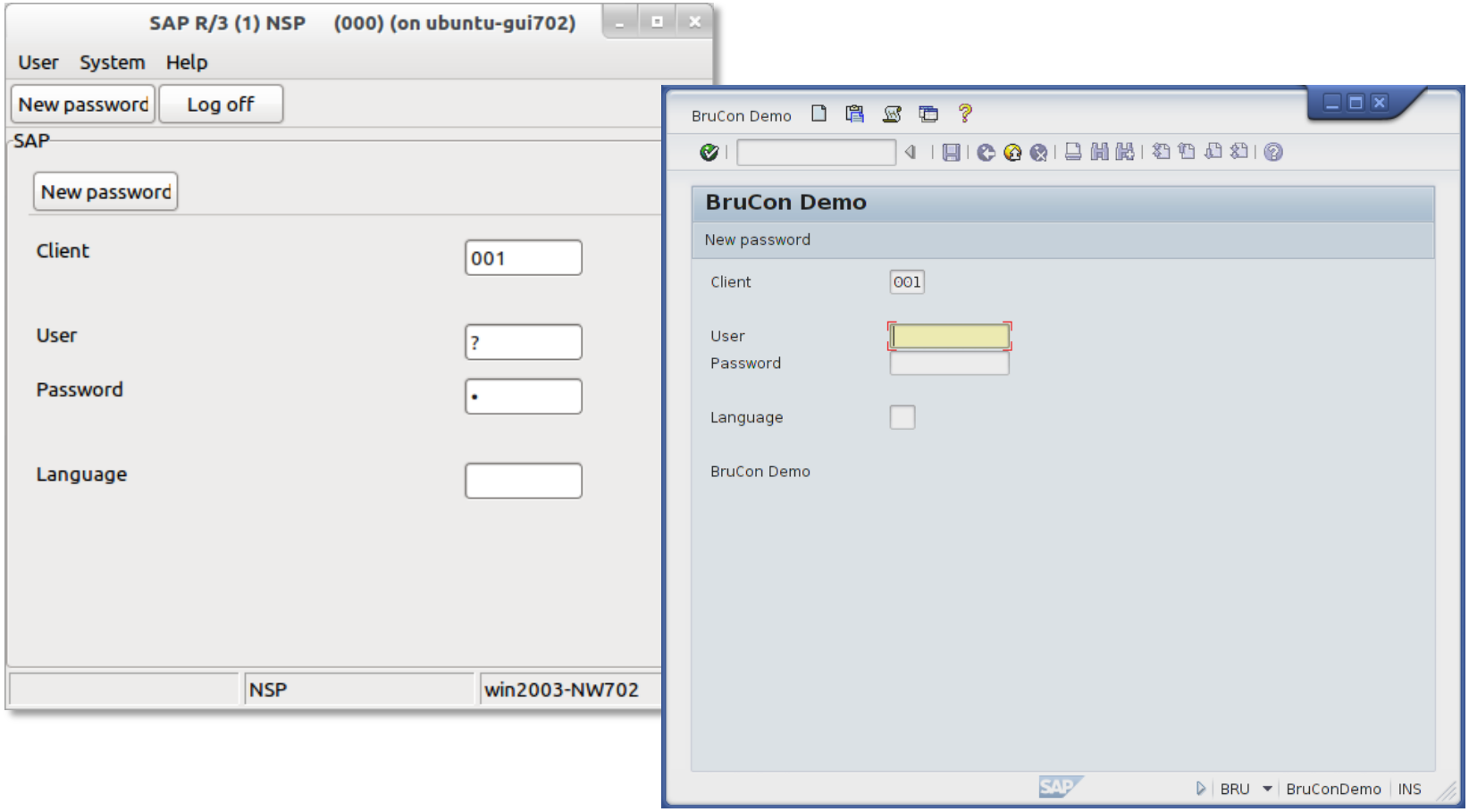
Packet crafting - pysap

- Scapy classes
  - SAPNi
  - SAPDiagDP (DP Header)
  - SAPDiag (Diag header + compression)
  - SAPDiagItem
  - Custom classes for relevant Diag items
  - C++ extension for compression/decompression
- PoC and example scripts
  - Information gathering
  - Login Brute Force
  - Proxy/MITM script
  - Diag server

http://corelabs.coresecurity.com/index.php?module=Wiki&action=view&type=tool&name=pysap

Packet crafting - pysap



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Fuzzing approach

- Fuzzing scheme using
  - scapy classes - pysap
    - test cases generation
    - delivery
  - windbg
    - monitoring
  - xmlrpc
    - syncronization
- Monitoring of all work processes

Vulnerabilities found

- 6 vulnerabilities released on May 2012 affecting SAP NW 7.01/7.02, fix available on SAP Note 168710

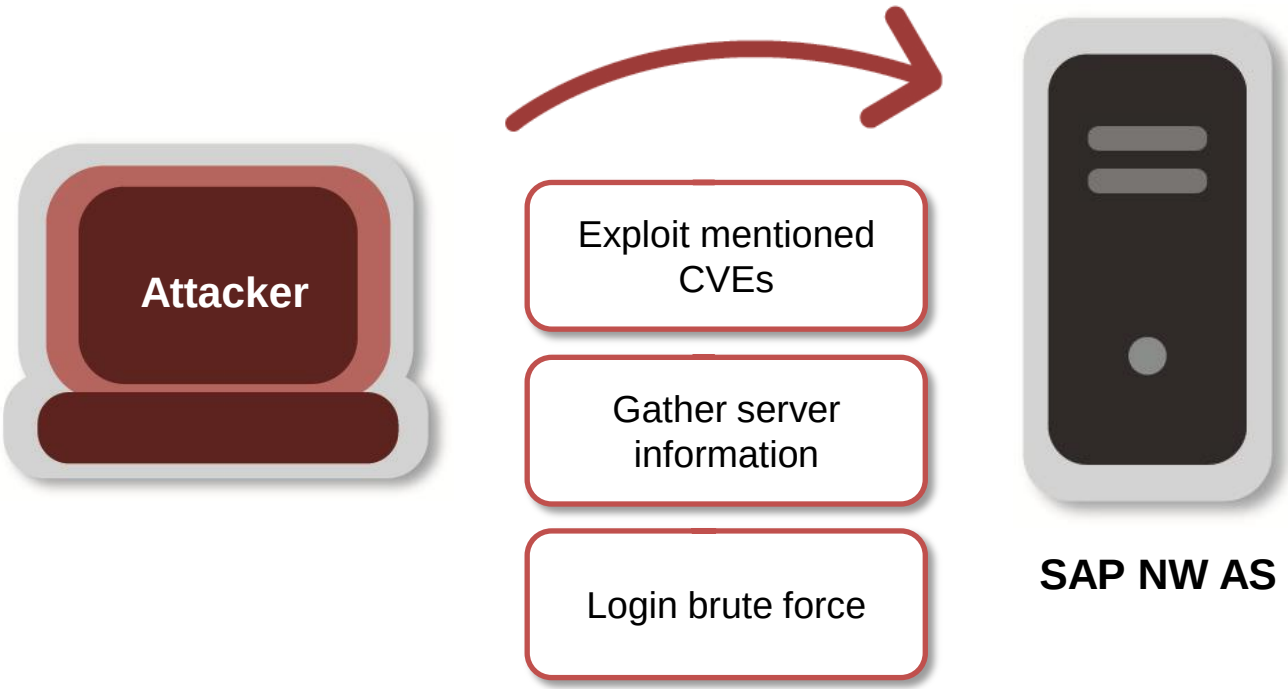
- Unauthenticated remote denial of service when developed traces enabled
    - CVE-2012-2511 – DiagTraceAtoms function
    - CVE-2012-2512 – DiagTraceStreamI function
    - CVE-2012-2612 – DiagTraceHex function

Vulnerabilities found

- Unauthenticated remote denial of service
  - CVE-2012-2513 – Diaginput function
  - CVE-2012-2514 – DiagiEventSource function
- Unauthenticated remote code execution when developer traces enabled
  - CVE-2012-2611 – DiagTraceR3Info function
    - Stack-based buffer overflow while parsing ST_R3INFO CODEPAGE item
    - Thanks to Francisco Falcon (@fdfalcon) for the exploit
    - Exploit available since May on CORE Impact, Sept on MSF

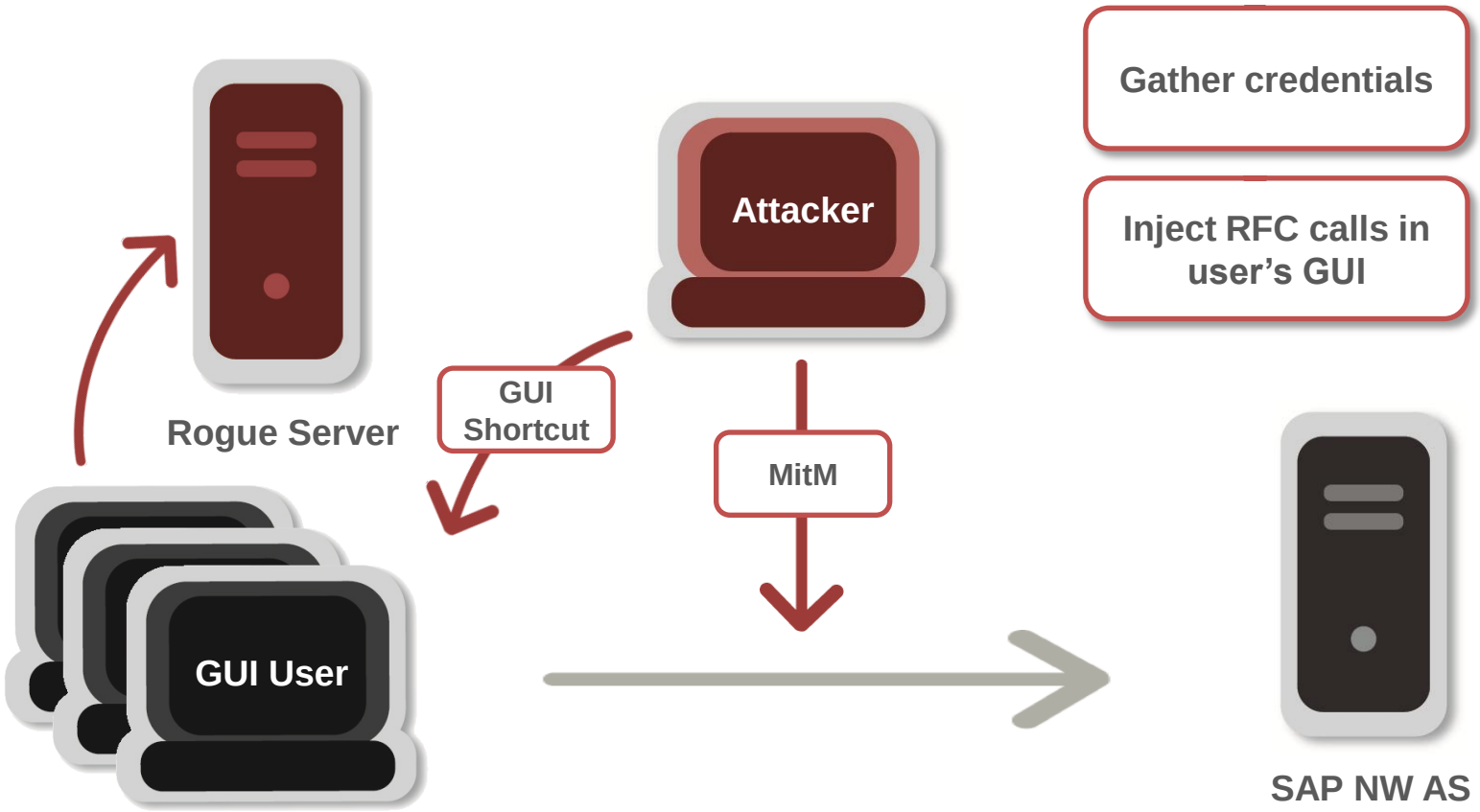
Attack scenarios

Target applications servers



Attack scenarios

Target GUI users



Recent changes

- Main changes since first release (Defcon / July-2012)
  - sap plugin for Wireshark
    - Fixes on the SAP Router dissector and support for Admin messages (thanks @nmonkee)
    - Minor fixes and improvements
  - pysap
    - More documentation
    - Minor fixes and improvements

- Still working on
  - sap plugin for Wireshark
    - Remove C++ requirement (thanks @jproliers)
    - Add dissection for more Diag items
    - Improve RFC dissection
  - pysap
    - Rogue server PoC on SAP Gui for Windows/SAP GUI Java
    - More example scripts…

Defenses and countermeasures

Defenses and countermeasures

- Restrict network access to dispatcher service
  - TCP ports 3200-3298
  - Use application layer gateways
- Implement SNC client encryption
  - Provides authentication and encryption
  - Available for free at SAP Marketplace since 2011
  - See SAP Note 1643878
- Restrict use of GUI shortcuts
  - SAP GUI > 7.20 disabled by default
  - See SAP Note 1397000

Defenses and countermeasures

- Use WebGUI with HTTPS
  - See SAP Note 314568
- Patch regularly
  - Patch Tuesday
  - RSECNOTE program, see SAP Note 888889
- Patch CVEs affecting Diag
  - Look at CORE's advisory for mitigation/countermeasures
  - See SAP Note 168710
- Test regularly

Conclusion and future work

Conclusion

- Protocol details now available to the security community
- Practical tools for dissection and crafting of protocol's messages published
- New vectors for testing and assessing SAP environments
- Discussed countermeasures and defenses

Future work

- Security assessment and fuzzing of GUI/app server
- Complete dissection of embedded RFC calls
- Full implementation of attack scenarios
- Integration with external libraries and exploitation tools
- Security assessment of SNC and coverage of encrypted traffic

Q & A

Thank you !

mgallo@coresecurity.com

Thanks to
Diego, Flavio, Dana, Wata and Euge

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References

https://service.sap.com/sap/support/notes/1643879
http://www.secaron.de/Content/presse/fachartikel/sniffing_diag.pdf
http://conus.info/RE-articles/sapgui.html
http://www.sensepost.com/labs/conferences/2011/systems_application_proxy_pwnage
http://ptresearch.blogspot.com/2011/10/sap-diag-decompress-plugin-for.html
http://www.oxid.it/index.html
https://service.sap.com/securitynotes
http://help.sap.com/saphelp_nw70/helpdata/en/84/54953fc405330ee10000000a114084/frameset.htm
http://www.troopers.de/wp-content/uploads/2011/04/TR11_Wiegenstein_SAP_GUI_hacking.pdf
http://www.virtualforge.com/tl_files/Theme/Presentations/The%20ABAP%20Underverse%20-%20Slides.pdf
http://www.wireshark.org/
http://corelabs.coresecurity.com/index.php?module=Wiki&action=view&type=tool&name=SAP_Dissection_plugin_for_Wireshark
http://www.secdev.org/projects/scapy/
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http://www.coresecurity.com/content/sap-netweaver-dispatcher-multiple-vulnerabilities
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