The ABAP Underverse

Risky ABAP to Kernel Communication & ABAP-tunneled buffer overflows

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"Hailing frequencies open."

Virtual Forge GmbH

- SAP security product company based in Heidelberg, Germany
- Focus on (ABAP) application security services
  - ABAP Security Scanner
  - ABAP Security Guidelines
  - ABAP Security Trainings
  - SAP Security Consulting

Andreas Wiegenstein

- CTO and founder of Virtual Forge, responsible for R&D
- SAP Security Researcher, active since 2003
- Speaker at SAP TechEd 2004, 2005, 2006, DSAG 2009, …
- Co-Author of "Secure ABAP Programming" (SAP Press)

Belief: „Our SAP system is secure.“

- Roles & Authorizations
- Segregation of Duties
- Secure Configuration & System / Service Hardening
- Encryption
- Secure Network Infrastructure
- Password Policies
- Patch Management
- Identity Management
- Single Sign-on

SUPER-GREEN!

Reality-Check

"...and this is our ABAP security department."

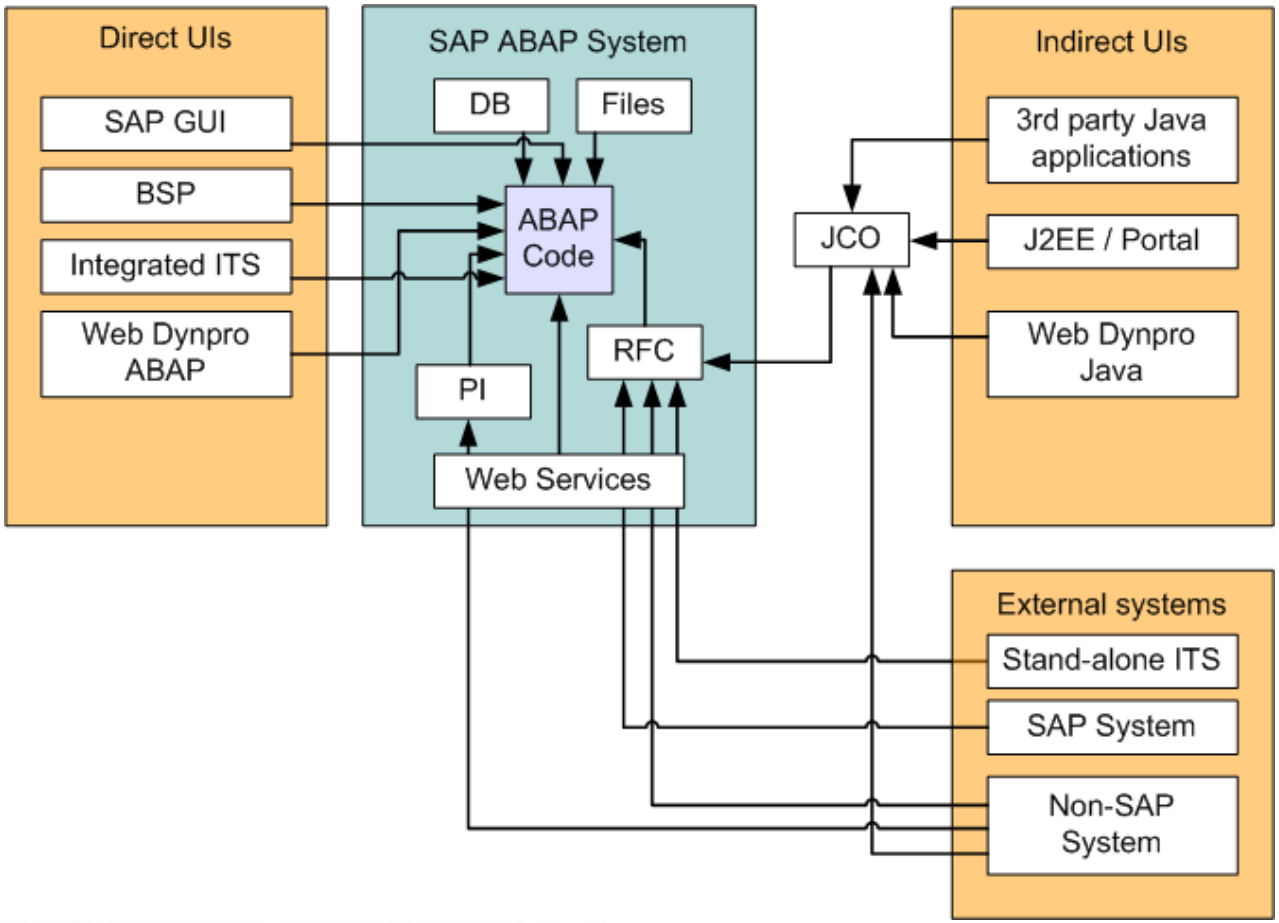
Advanced **B**usiness **A**pplication **P**rogramming

Fundamentals

- Proprietary language, exact specification not (freely) available
- Platform-independent code
- Client separation built-in
- Integrated auditing capabilities
- System-to-System calls via SAP RFC standard
- Built-in transport system and version control
- Various programming paradigms:
  - Programs & Forms, Reports, Function Modules, Dynpros
  - Classes & Methods, Business Server Pages, Web Dynpro ABAP

- Integrated platform-independent SQL Standard: Open SQL
- Built-in authentication, roles and (explicit) authorization model
- Thousands of well-known standard programs and database tables
- 150+ Million Lines of Code in an ECC6.0 System

ABAP's Attack Surface

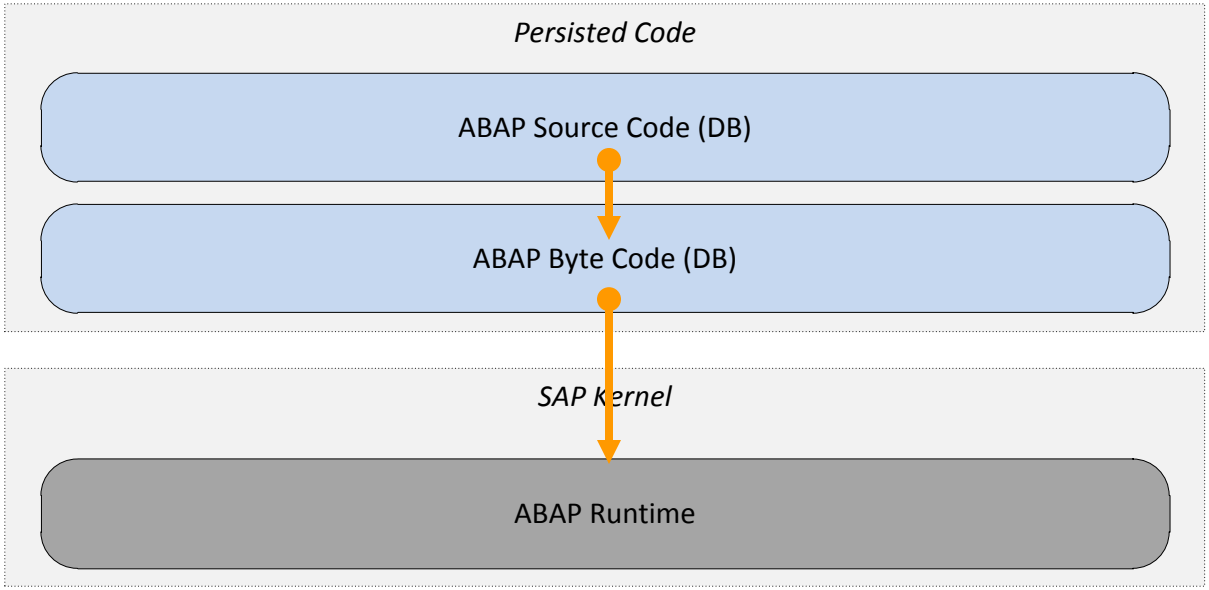


ABAP Security Risks

- Back Doors
  - Intentional bugs, e.g. malicious developer or spy
- Side-effects
  - Unintentional bugs, e.g. due to lack of knowledge
- Insecure alternatives to SAP standard security mechanisms

The ABAP Runtime

(theoretical behavior)



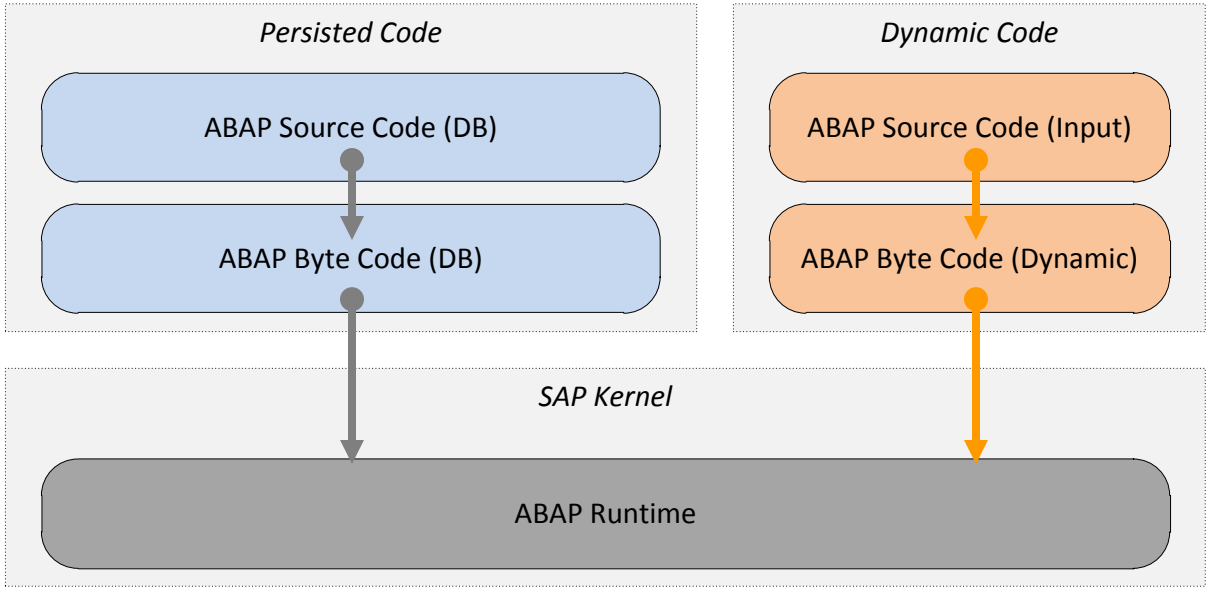
Static ABAP examples

```
REPORT ZSTATIC_ASSIGN.
DATA lv_secret TYPE string.
FIELD-SYMBOLS <fs> TYPE ANY.
PARAMETERS lv_tmp TYPE string DEFAULT 'Bishop'.

ASSIGN lv_tmp TO <fs>.
```

```
REPORT ZSTATIC_DELETE.
DELETE FROM usr02 WHERE bname = sy-uname.
```

The ABAP Runtime
(dynamic ABAP commands)



Dynamic ABAP example #1

```
REPORT ZDYNAMIC_ASSIGN.
DATA lv_secret TYPE string VALUE 'ZFT'.
DATA lv_share TYPE string VALUE 'Bishop'.
FIELD-SYMBOLS <fs> TYPE ANY.
PARAMETERS lv_tmp TYPE string DEFAULT 'lv_share'.

ASSIGN (lv_tmp) TO <fs>.
```

Hack #1: **lv_secret**

Hack #2: **sy-opsys**

GENERIC VARIABLE READER

Dynamic ABAP example #2

```
REPORT ZDYNAMIC_DELETE.
PARAMETERS lv_tmp TYPE string
                  DEFAULT 'bname = sy-uname'.

DELETE FROM usr02 WHERE (lv_tmp).
```

Bad Hack: `1 = 1`

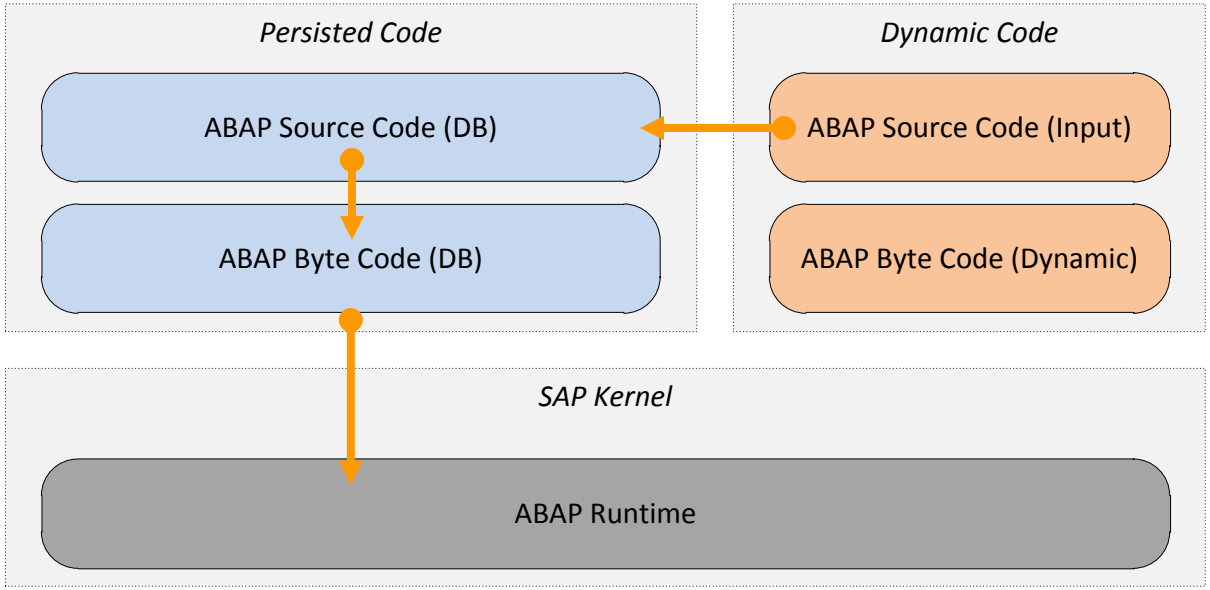
Better Hack: `mandt = sy-mandt`

Good Hack:

OPEN SQL INJECTION

The ABAP Runtime

(persisted code generation)



Persisted code generation

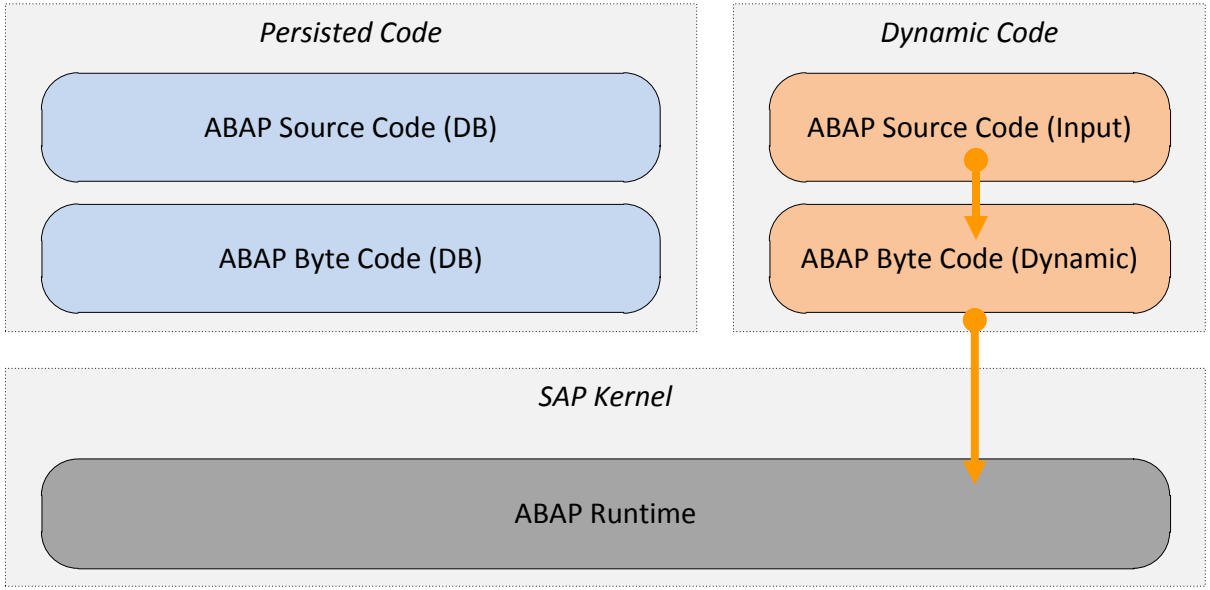
```
REPORT ZPERSISTED_ABAP.
DATA: lt_prog(97) OCCURS 0 WITH HEADER LINE.
PARAMETERS lv_name TYPE string.

lt_prog = 'REPORT ZFT.'.      APPEND lt_prog.
CONCATENATE `DATA lv_tmp(82) TYPE c VALUE '`
  lv_name `'.` INTO lt_prog. APPEND lt_prog.
lt_prog = 'WRITE / lv_tmp.'. APPEND lt_prog.

INSERT REPORT 'ZFT' FROM lt_prog.
GENERATE REPORT 'ZFT'.
SUBMIT ('ZFT').
```

ABAP CMD INJECTION

The ABAP Runtime
(dynamic code generation)



Dynamic code generation

```
REPORT ZDYNAMIC_ABAP.
DATA: prog(72) OCCURS 0 WITH HEADER LINE.
DATA: pool(20) TYPE c.
PARAMETERS lv_name TYPE string.
prog = 'REPORT MASSIVEDYNAMIC.'.      APPEND prog.
prog = 'FORM BELL.'.                  APPEND prog.
prog = 'DATA name TYPE string.'.      APPEND prog.
CONCATENATE `name = '` lv_name `'.  `
  INTO prog.                          APPEND prog.
prog = 'WRITE : / ''Hello '', name.'. APPEND prog.
prog = 'ENDFORM.'.                    APPEND prog.
GENERATE SUBROUTINE POOL prog NAME pool.
PERFORM ('BELL') IN PROGRAM (pool).
```

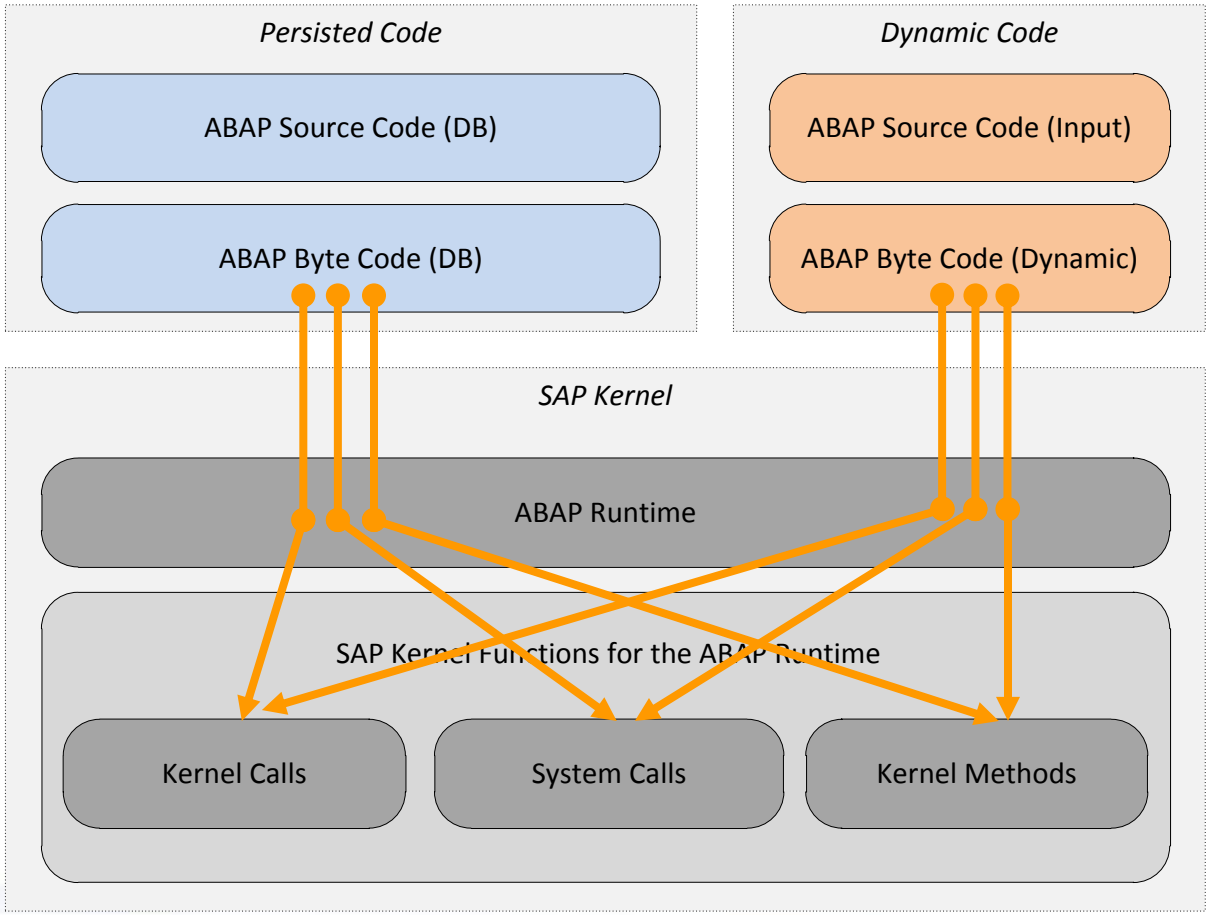
ABAP CMD INJECTION

ABAP code generation risks

- ABAP developer right = "root" access
- Silent way to acquire "SAP ALL" privileges takes 56 characters.
- Noisy way to acquire "SAP ALL" privileges takes 34 characters.
- *Entire SAP system must be considered compromised in case of an ABAP Command Injection vulnerability*

The ABAP Runtime

(Kernel Communication)



Kernel Communication

- High-performant pool of helper functions
- Should only be used by SAP
- Can be explicitly invoked from ABAP
- Mostly undocumented functionality
- Three types of Kernel functions exist:
  - Kernel Calls
  - System Calls
  - Kernel Methods

Kernel Calls

```
REPORT ZKERNEL_CALL.
DATA lv_dbhost LIKE msxxlist-host.
CALL 'C_SAPGPARAM' ID 'NAME' FIELD 'SAPDBHOST'
                   ID 'VALUE' FIELD lv_dbhost.
```

- 370+ different Kernel Calls in ECC 6.0
- In general, no implicit authority check
- Importing / Exporting parameter not obvious

System Calls

```
REPORT ZSYSTEM_CALL.
DATA: lv_nam, lv_val TYPE string.
DATA: m_err          TYPE i.
DATA: m_c_msg        TYPE %_c_pointer.

lv_name = 'chevron_V'.
SYSTEM-CALL ICT DID 11
  PARAMETERS m_c_msg lv_nam lv_val m_last_err.
```

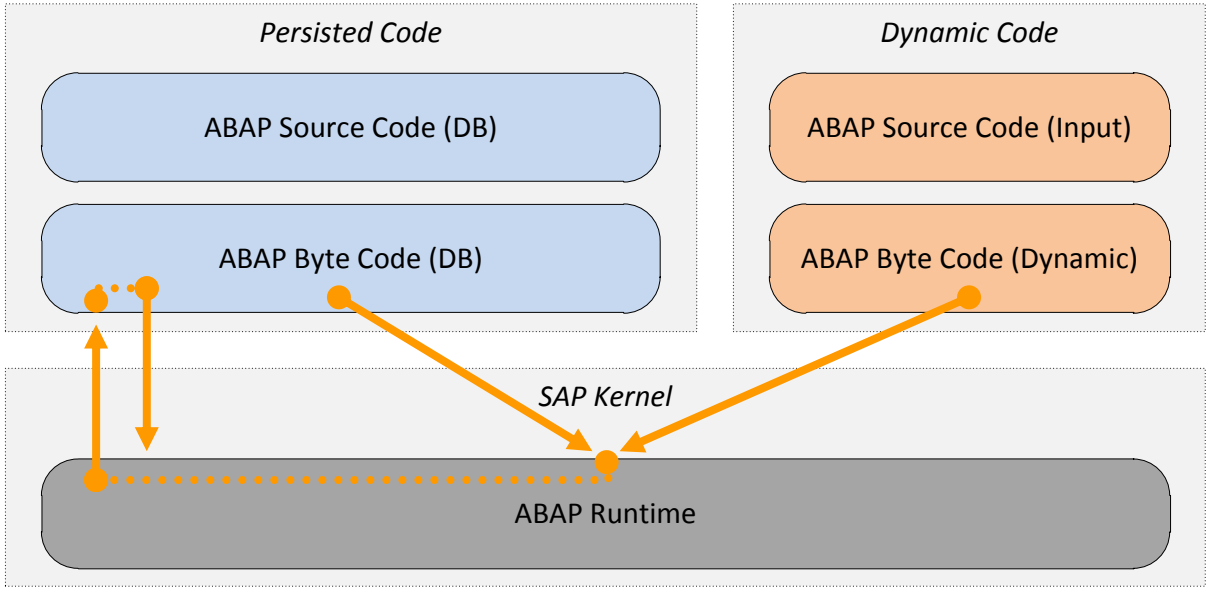
- Polymorph interface

Kernel Methods

```
METHOD convert BY KERNEL MODULE ab_expconvDbuf.
ENDMETHOD.
```

- Can't be declared by custom code
- Are called like normal methods
- Have typed parameters

The ABAP Runtime
(Kernel Hooks)



Kernel Hooks

- Kernel Hooks are ABAP subroutines (FORMs) called from the ABAP C/C++ Runtime.
- Data exchange works via Kernel Calls
- Multiple ABAP commands use Kernel Hooks
  - OPEN DATASET
  - CONVERT TIME-STAMP
  - WRITE AS TIME-STAMP
  - …

Kernel Hooks example (part 1)

```
FORM SYSTEM_HOOK_ZFT.

FIELD-SYMBOLS:  <P1> type any, <P2> type any,
                <P3> type any, <P4> type any,
                <R1> TYPE I, <R2> LIKE SY-SUBRC.

* First, pop the Kernel parameters from the stack
CALL 'AB_GET_C_PARMS' ID 'P1' field <P1>
                      ID 'P2' field <P2>
                      ID 'P3' field <P3>
                      ID 'P4' field <P4>.
```

Kernel Hooks example (part 2)

```
* Next, call a function to process the data

CALL FUNCTION 'ZPROCESS_THIS_STUFF'
  EXPORTING date  = <P1>
            time  = <P2>
            hour  = <P3>
            mint  = <P4>
  IMPORTING res   = <R1>
            subrc = <R2>
  EXCEPTIONS NO_PERMISSION.
```

Kernel Hooks example (part 3)

```
* Finally, push the results onto the Kernel stack
and exit the hook

CALL 'AB_SET_C_PARMS' ID 'P1' FIELD <R1>
                      ID 'P2' FIELD <R2>.

ENDFORM.
```

Kernel Hooks risks

- Malicious code can attach itself to the execution of ABAP commands that use Kernel Hooks

Whoever experiments with this: don't call the ABAP command you're hooked in…

Risky Kernel Calls (8 out of 370+)

Kernel Call	Risk
'SYSTEM'	OS command execution
'XXPASS' & 'XXPASSNET'	Compute password hash
'INTERNET_USER_LOGON'	Brute force credentials
'C_GET_TABLE'	Unauthorized table read access
'C_MOD_TABLE'	Unauthorized table write access
'C_DB_EXECUTE'	SQL Injection; DB modification
'C_DB_FUNCTION'	SQL Injection; DB modification

CALL 'SYSTEM'

```
CALL 'SYSTEM' ID 'COMMAND' FIELD lv_cmd
              ID 'TAB' FIELD lt_result-*sys*.
```

- ID 'COMMAND' defines OS command
- ID 'TAB' receives output (optional)
- *Implicit* auth check in Kernel (S_C_FUNCT)
- Can be disabled by setting profile parameter ‘rdisp/call_system’ to ‘0’
- *Not the only way to execute OS commands!*

CALL 'XXPASS' / 'XXPASSNET'

```
CALL 'XXPASS' ID 'CODE'     FIELD 'akagi'
              ID 'NAME'     FIELD 'castle'
              ID 'CODX'     FIELD lv_hash
              ID 'PASSCODE' FIELD lv_pass
              ID 'VERS'     FIELD lv_vers.
```

- ID 'CODX' returns the hash value
- Terminates session and locks user account
- Defensive reaction depends on name(space) of the calling program (Y*, Z* problematic)

CALL 'INTERNET_USER_LOGON'

```
CALL 'INTERNET_USER_LOGON'
  ID 'UNAME'     FIELD lv_userid
  ID 'PASSW'     FIELD lv_password
  ID 'TICKET'    FIELD lv_ticket
  ID 'PASSFLAG' FIELD lv_pwdstate.
```

- Performs user switch & creates logon ticket
- Can check credentials only (TESTMODE)
- Keeps track of failed login attempts

CALL 'C_GET_TABLE'

```
CALL 'C_GET_TABLE'
   ID 'TABLNAME'   FIELD lv_tab
   ID 'INTTAB'     FIELD lt_tab-*sys*
   ID 'GENKEY'     FIELD lv_key
   ID 'GENKEY_LN' FIELD lv_keylen
   ID 'BYPASS'     FIELD lv_bypass.
```

- Low-level direct access to database tables
- Cross-Client data access

CALL 'C_MOD_TABLE'

```
CALL 'C_MOD_TABLE'
   ID 'TABLNAME' FIELD lv_tab
   ID 'INTTAB'   FIELD lt_tab-*sys*
   ID 'FCODE'    FIELD 'U'
   ID 'DBCNT'    FIELD lv_dbcnt
   ID 'SQLCODE'  FIELD lv_sqlcode.
```

- Low-level direct access to database tables
  - U(pdate), I(nsert) or D(elete) table rows
- Cross-Client data access

CALL 'C_DB_EXECUTE'

```
CALL 'C_DB_EXECUTE' ID 'STATLEN' FIELD lv_len
                    ID 'STATTXT' FIELD lv_stmt
                    ID 'SQLERR'  FIELD lv_sqlerr.
```

- Executes an *arbitrary* SQL command
  - (Except SELECT)
- Cross-Client data access
- Can gain full control over SAP database

CALL 'C_DB_FUNCTION' #1

```
CALL 'C_DB_FUNCTION' ID 'FUNCTION' FIELD 'DB_SQL'
                     ID 'FCODE'    FIELD 'EP'
                     ID 'PROCNAME' FIELD lv_proc
                     ...
```

- Executes an *arbitrary* stored procedure
- Can gain full control over SAP database

CALL 'C_DB_FUNCTION' #2

```
CALL 'C_DB_FUNCTION' ID 'FUNCTION' FIELD 'DB_SQL'
                     ID 'FCODE'    FIELD 'PO'
                     ID 'STMT_STR' FIELD lv_stat
                     ...
```

- Executes an *arbitrary* SQL statement
- Cross-Client data access
- Can gain full control over SAP database

Risky Kernel Calls

DEMO

Risky Kernel Calls Summary

- No (comprehensive) documentation
  - Unknown number of critical Kernel Calls
- Several known calls can bypass SAP security mechanisms
- Several 0 days wait for "responsible disclosure"
- *Kernel Calls must be addressed in ABAP security guidelines, development standards & security assessments: Don't use Kernel Calls*

Buffer overflows in Kernel Calls

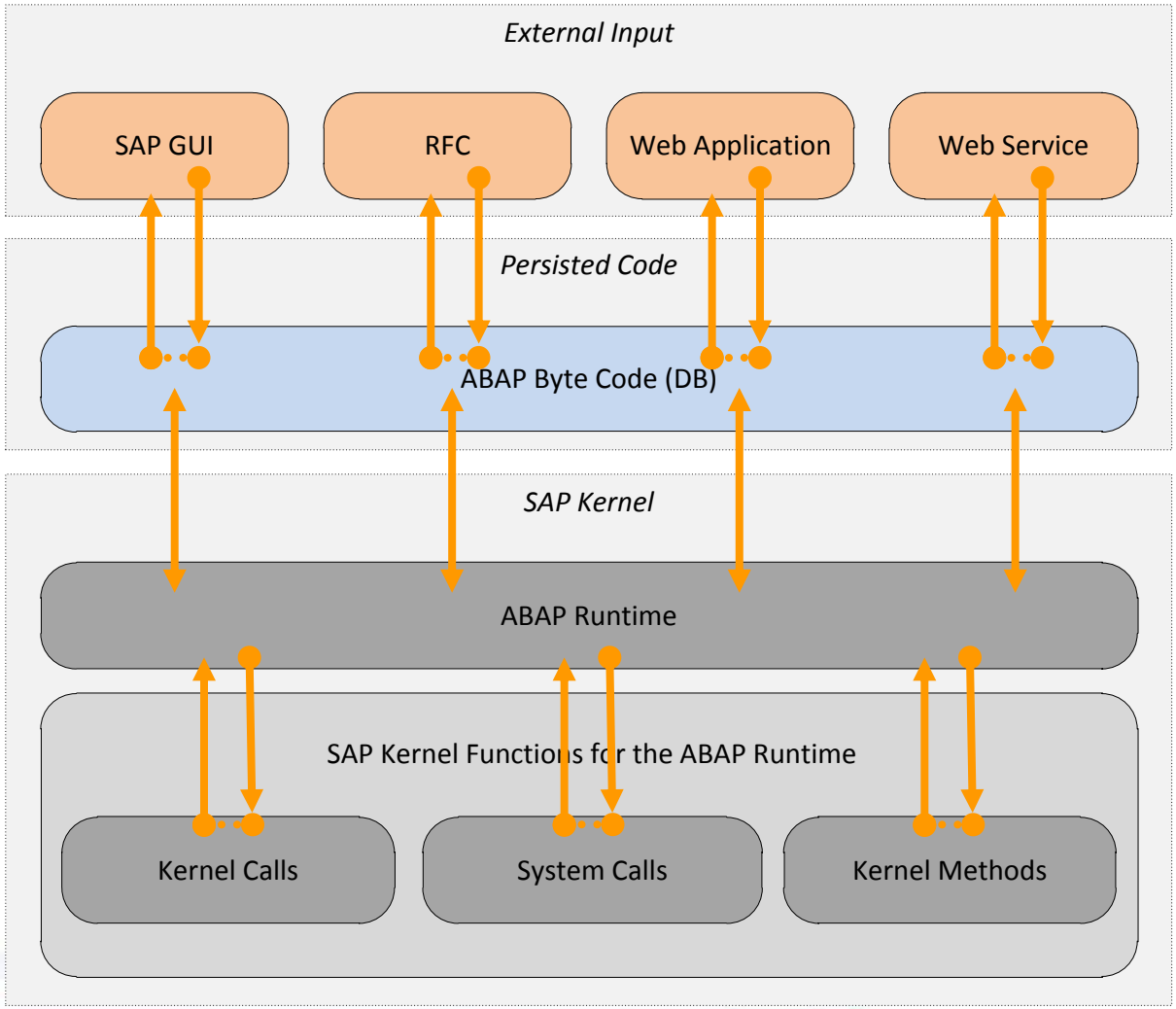
- Kernel Calls can't be accessed remotely
- ABAP has automatic memory management – bad news for "buffer overflow exploiters"

But...

- (Custom) ABAP programs can expose Kernel Calls to external input

➢ Attackers must find a data flow path to a vulnerable parameter of a Kernel Call

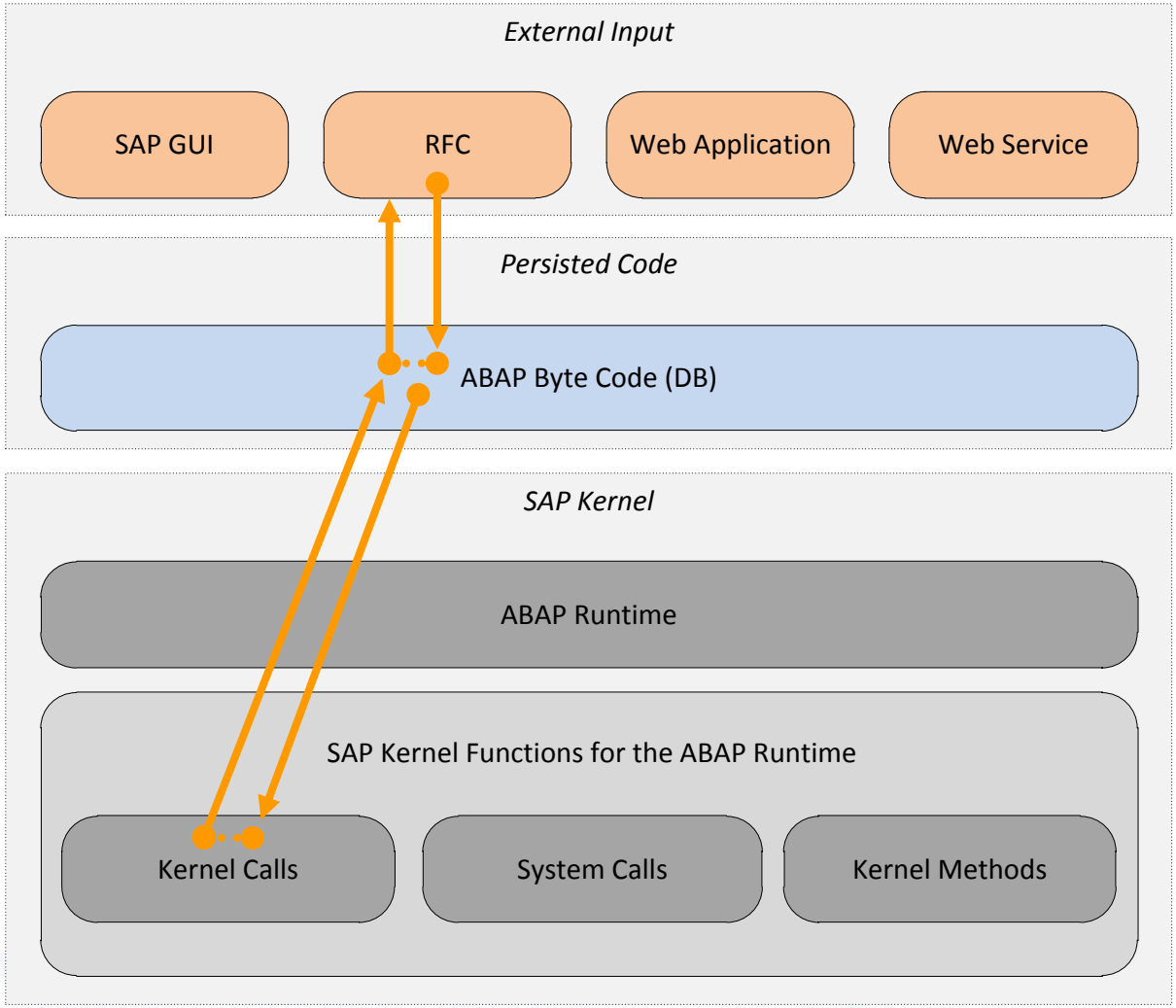
ABAP Runtime shields Kernel Calls



Buffer overflow risks

- An attacker may find a way to pass input to a vulnerable Kernel or System Call
- Since Kernel / Systems Calls can only be executed by ABAP commands, an exploit needs to be tunneled through the ABAP code
- The risk increases, if the "ABAP tunnel" can be invoked remotely, e.g. via RFC or a Web page.

ABAP-tunneled Buffer Overflows



Buffer overflows in Kernel Calls (1)

```
CALL 'C_SAPGDEFPARAM' ID 'NAME'  FIELD lv_buffy
                      ID 'VALUE' FIELD lv_dummy.
```

- Buffer overflow* in **NAME** with > 103 chars
- Exposed by RFC-enabled function module
- But data-type is a TEXT60 only.

Buffer overflows in Kernel Calls (2)

```
CALL 'BUILD_DS_SPEC' ID 'FILENAME' FIELD lv_buffy
                     ID 'PATH'     FIELD lv_buffy
                     ID 'OPSYS'    FIELD lv_buffy
                     ID 'RESULT'   FIELD lv_na.
```

- Buffer overflow* in **NAME** with > 404 chars
- Buffer overflow* in **PATH** with > 204 chars
- Buffer overflow* in **OPSYS** with > 428 chars
- Exposed by RFC-enabled function module
- But data-type is a TEXT80 only.

Buffer overflow in System Calls

```
SYSTEM-CALL ICT DID 29
   PARAMETERS
      lv_buff1 lv_buff2 lv_dummy lv_dummy
      lv_dummy lv_dummy lv_dummy lv_dummy.
```

- Buffer overflow* in parameter 1 & 2 with > 200 characters
- Not exposed

Exposed Buffer overflow in a Kernel Call

```
CALL 'C_SAPGPARAM' ID 'NAME'  FIELD lv_buffy
                   ID 'VALUE' FIELD lv_dummy.
```

- Buffer overflow* in **NAME** with > 108 chars
- Exposed by RFC-enabled function module
- Data-type is a TEXT255 ☺

Buffer Overflow PoC

DEMO

Buffer overflow protection steps

1) Pick a Kernel / System Call and identify its importing parameters
2) Send overlong input and check if the ABAP work-thread dies
3) Check where this Kernel / System Call is used (in the SAP standard) and which data types are used in the data flow path
4) Test if overlong user input can reach the vulnerable Kernel / System Call
5) Block access to the vulnerable ABAP code or use a data type that is too short for an exploit

Summary

There are severe security risks in ABAP, too:

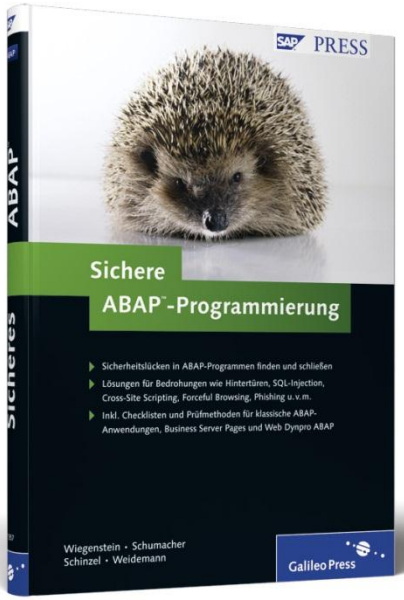
- (Custom) ABAP Code can bypass security features of the SAP standard and thereby violate regulatory compliance.
- Kernel Calls provide lots of (undocumented) functionality that can bypass SAP security mechanisms
- Kernel Calls can also introduce (remote exploitable) buffer overflow risks

Secure ABAP Development

Organizations

BIZEC – Business Security Initiative
http://www.bizec.org

Literature



"Secure ABAP-Programming"
(German only)
SAP Press 2009

SAP Security Notes

- SAP Security Note 1493516 – "Correcting buffer overflow in ABAP system call"
  - Covers the buffer overflow in the SYSTEM-CALL
- SAP Security Note 1487330 – "Potential remote code execution in SAP Kernel"
  - Covers the 5 buffer overflows in the Kernel Calls

Q & A

"... So, after all these slides, you must have lots of questions to ask. Am I right?"

"Yes, of course.

Lots of questions."

"… Well. What are they?"

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