Course Information

SSP-RS — Safe System Programming (in Rust)

Samuel Tardieu Stefano Zacchiroli

2024-09-17

Objectives

What you will learn

In this course you will learn how to build **system-level applications** that avoid by construction **memory safety issues** and **data race issues**, by relying on modern type systems.
You will be introduced to **Rust** as an example of a programming language that realizes this approach and has significant industry adoption.

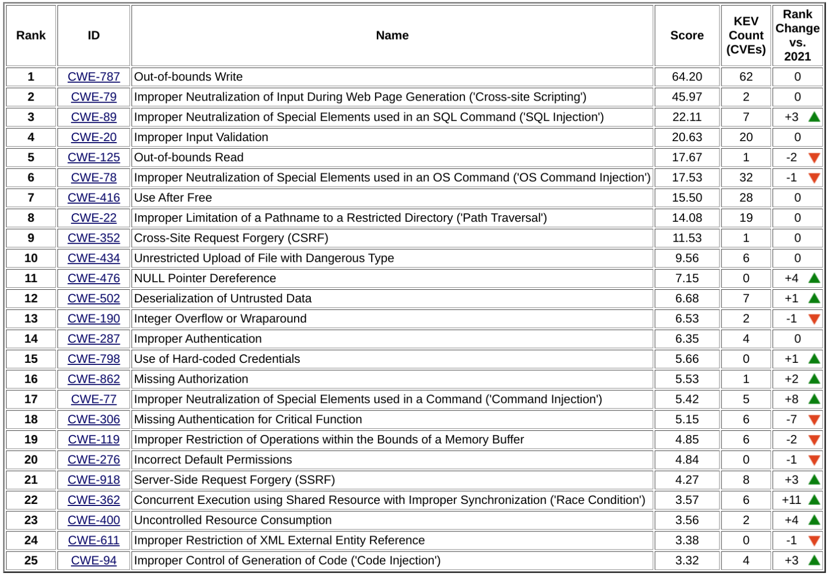
Prerequisites

- Fundamentals of operating systems
- C programming (C++ would be a plus)
- POSIX programming
- Some experience with multithreading/multiprocessing programming

Syllabus

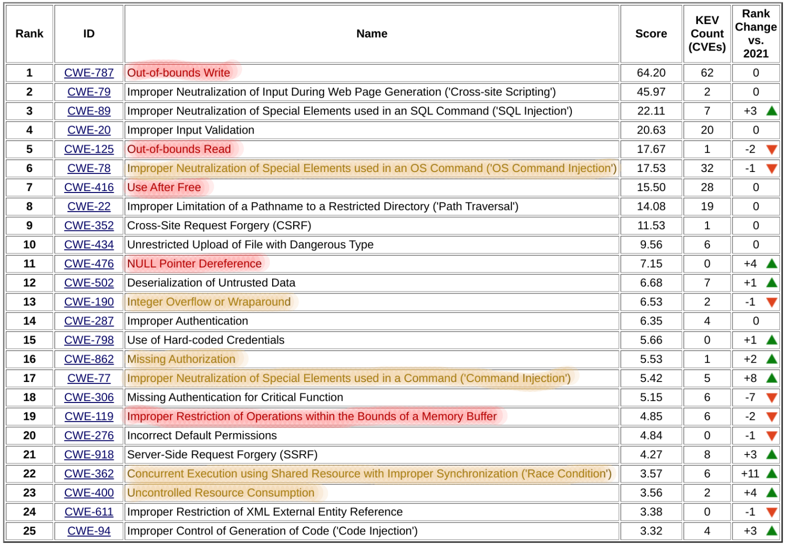
- Memory safety
- How to detect memory-safety issues in C/C++
- The Rust memory model
- NULL references and how to avoid “billion dollar mistakes”
- Rust language basics
- Hardening Rust code (including: testing, fuzzing, supply chain)
- Race conditions
- Avoiding multithreading (security) pitfalls
- Data races
- Avoiding multiprocessing (security) pitfalls

2022 CWE Top 25 — redux



Rank	ID	Name	Score	KEV Count (CVEs)	Rank Change vs. 2021
1	CWE-787	Out-of-bounds Write	64.20	62	0
2	CWE-79	Improper Neutralization of Input During Web Page Generation ('Cross-site Scripting')	45.97	2	0
3	CWE-89	Improper Neutralization of Special Elements used in an SQL Command ('SQL Injection')	22.11	7	+3 ▲
4	CWE-20	Improper Input Validation	20.63	20	0
5	CWE-125	Out-of-bounds Read	17.67	1	-2 ▼
6	CWE-78	Improper Neutralization of Special Elements used in an OS Command ('OS Command Injection')	17.53	32	-1 ▼
7	CWE-416	Use After Free	15.50	28	0
8	CWE-22	Improper Limitation of a Pathname to a Restricted Directory ('Path Traversal')	14.08	19	0
9	CWE-352	Cross-Site Request Forgery (CSRF)	11.53	1	0
10	CWE-434	Unrestricted Upload of File with Dangerous Type	9.56	6	0
11	CWE-476	NULL Pointer Dereference	7.15	0	+4 ▲
12	CWE-502	Deserialization of Untrusted Data	6.68	7	+1 ▲
13	CWE-190	Integer Overflow or Wraparound	6.53	2	-1 ▼
14	CWE-287	Improper Authentication	6.35	4	0
15	CWE-798	Use of Hard-coded Credentials	5.66	0	+1 ▲
16	CWE-862	Missing Authorization	5.53	1	+2 ▲
17	CWE-77	Improper Neutralization of Special Elements used in a Command ('Command Injection')	5.42	5	+8 ▲
18	CWE-306	Missing Authentication for Critical Function	5.15	6	-7 ▼
19	CWE-119	Improper Restriction of Operations within the Bounds of a Memory Buffer	4.85	6	-2 ▼
20	CWE-276	Incorrect Default Permissions	4.84	0	-1 ▼
21	CWE-918	Server-Side Request Forgery (SSRF)	4.27	8	+3 ▲
22	CWE-362	Concurrent Execution using Shared Resource with Improper Synchronization ('Race Condition')	3.57	6	+11 ▲
23	CWE-400	Uncontrolled Resource Consumption	3.56	2	+4 ▲
24	CWE-611	Improper Restriction of XML External Entity Reference	3.38	0	-1 ▼
25	CWE-94	Improper Control of Generation of Code ('Code Injection')	3.32	4	+3 ▲

2022 CWE Top 25 vs this course



Rank	ID	Name	Score	KEV Count (CVEs)	Rank Change vs. 2021
1	CWE-787	Out-of-bounds Write	64.20	62	0
2	CWE-79	Improper Neutralization of Input During Web Page Generation ('Cross-site Scripting')	45.97	2	0
3	CWE-89	Improper Neutralization of Special Elements used in an SQL Command ('SQL Injection')	22.11	7	+3 ▲
4	CWE-20	Improper Input Validation	20.63	20	0
5	CWE-125	Out-of-bounds Read	17.67	1	-2 ▼
6	CWE-78	Improper Neutralization of Special Elements used in an OS Command ('OS Command Injection')	17.53	32	-1 ▼
7	CWE-416	Use After Free	15.50	28	0
8	CWE-22	Improper Limitation of a Pathname to a Restricted Directory ('Path Traversal')	14.08	19	0
9	CWE-352	Cross-Site Request Forgery (CSRF)	11.53	1	0
10	CWE-434	Unrestricted Upload of File with Dangerous Type	9.56	6	0
11	CWE-476	NULL Pointer Dereference	7.15	0	+4 ▲
12	CWE-502	Deserialization of Untrusted Data	6.68	7	+1 ▲
13	CWE-190	Integer Overflow or Wraparound	6.53	2	-1 ▼
14	CWE-287	Improper Authentication	6.35	4	0
15	CWE-798	Use of Hard-coded Credentials	5.66	0	+1 ▲
16	CWE-862	Missing Authorization	5.53	1	+2 ▲
17	CWE-77	Improper Neutralization of Special Elements used in a Command ('Command Injection')	5.42	5	+8 ▲
18	CWE-306	Missing Authentication for Critical Function	5.15	6	-7 ▼
19	CWE-119	Improper Restriction of Operations within the Bounds of a Memory Buffer	4.85	6	-2 ▼
20	CWE-276	Incorrect Default Permissions	4.84	0	-1 ▼
21	CWE-918	Server-Side Request Forgery (SSRF)	4.27	8	+3 ▲
22	CWE-362	Concurrent Execution using Shared Resource with Improper Synchronization ('Race Condition')	3.57	6	+11 ▲
23	CWE-400	Uncontrolled Resource Consumption	3.56	2	+4 ▲
24	CWE-611	Improper Restriction of XML External Entity Reference	3.38	0	-1 ▼
25	CWE-94	Improper Control of Generation of Code ('Code Injection')	3.32	4	+3 ▲

You will learn how to avoid *by design* the CWEs highlighted in red using modern type systems and programming language technology. (And, to a lesser extent, how to avoid or mitigate the CWE highlighted in orange, and more.)

Team

Samuel Tardieu

- Associate Professor at Télécom Paris, IP Paris, team ACES
- Research: operating systems and schedulers, distributed systems, embedded systems and robotics
- Free software enthusiast and activist for 30 years
- Programming languages polyglot, with a preference for Rust, Haskell, Scala, Factor, and Scheme

Stefano Zacchiroli

- Full Professor at Télécom Paris, IP Paris, team ACES
- Research: free/open source software (FOSS) software engineering, digital commons, cybersecurity, software supply chain
- Co-founder and CSO of Software Heritage, the largest public archive of FOSS source code
- Tech and activism: Debian developer, former Debian project leader (2010-2013), former board director of the Open Source Initiative (OSI)

Evaluation

Final grade

50% written exam + 50% project assignment

Project assignment

- General idea: write for scratch or improve a secure and fast system application (written in Rust!) for a real-world use case.
- Project to be implemented either solo (1 student) or in pairs (2 students).
- Evaluation criteria: specification conformity, performances, robustness (including security), code quality.
- Evaluation methods: code review, testing, discussion of design/implementation choices with the teachers.

Project — practical information

- Shared pad available at https://partage.imt.fr/index.php/s/WSFBSkrdQ96Famg
- By **October 1st, 2024**, you should:
    - Add your group to the pad (under “Project groups”)
    - The entry should include the group members and a tentative project topic, that you propose to work on
- The proposed topic will then be discussed with and ultimately **validated by the teachers**, before being final.
- You should **propose your own topic**, one you are really excited about.
    - But we will also add a few predefined topics, in case you are really lost for ideas.
    - Each predefined topic can be assigned to only one group.

Organization

- **Weekly lectures** on Tuesday, usually (with exceptions):
  - 1 TH of lecture (*cours magistral*)
  - 1 TH of lab work (*TP*)

  Teacher will vary (S. Tardieu / S. Zacchiroli)

- **Personal or group work** on the project: on your own time.

  Try to allocate at least 3 hours/week to the project (on average), otherwise you won't make it.

Contacts

Practical information

→ on Synapses

Email

- For *everything* about the course: <ssp-rs-2425@listes.telecom-paris.fr> mailing-list
  - Both students and teachers are subscribed
  - Teachers will answer on-list to inquiries posted there by anyone, so that everybody benefit
  - Mutual help among students on-list is encouraged
- For private inquiries only (e.g., “I’m sick”):
  - Samuel Tardieu <samuel.tardieu@telecom-paris.fr>
  - Stefano Zacchiroli <stefano.zacchiroli@telecom-paris.fr>

Warning: private email inquiries that could have been asked via the mailing list will be ignored.

Course material

Homepage

https://ssp-rs.telecom-paris.fr/

Sub-pages linked from homepage for:

- Lecture slides (PDF)
  - Published *after* each lecture
- Lab assignments (HTML)
  - Published *before* each lab session

Good reads

System programming

1. Robert Love. Linux System Programming: Talking Directly to the Kernel and C Library, 2nd edition. O'Reilly Media, 2013.
2. Michael Kerrisk. The Linux Programming Interface: A Linux and UNIX System Programming Handbook. No Starch Press, 2010.

Rust programming

1. Steve Klabnik, Carol Nichols. The Rust Programming Language, 2nd edition. No Starch Press, 2023.
2. Jim Blandy, Jason Orendorff, Leonora F. S. Tindall. Programming Rust, 2nd Edition. O'Reilly Media, Inc. 2021.
3. Rust community, The Rustonomicon: The Dark Arts of Unsafe Rust

Question time

The floor is yours!

?