COMS E6998-9:

Software Security and Exploitation

Lecture 3: Design

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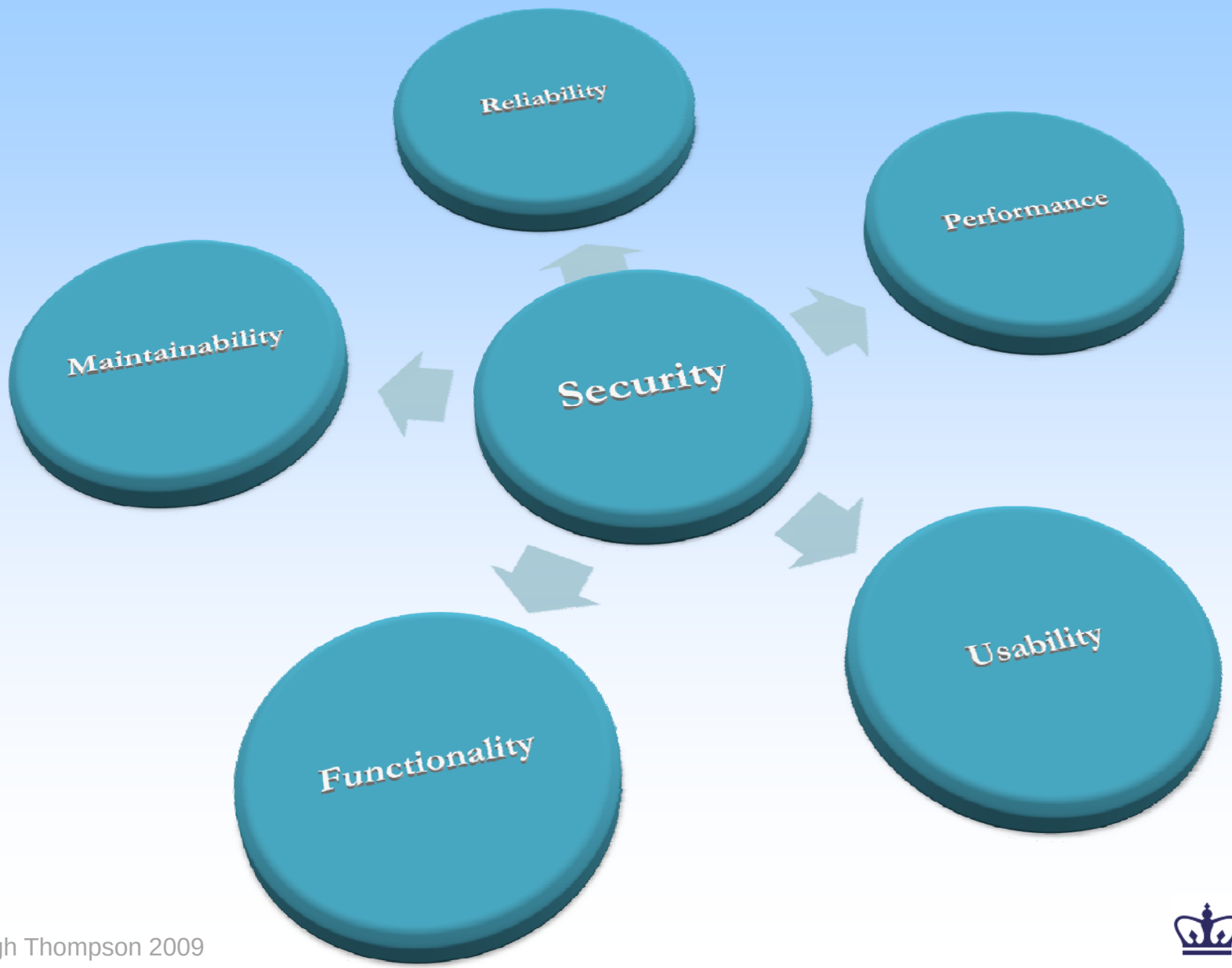
Design Principles

5. **Beware of the Economics of Security** – Need to consider the economics of attackers during design.
6. **Fail secure** – When software fails it need to consider security.
7. **Patchability** – Software need to be designed with update in mind.
8. **Determine security tradeoffs: Usability, Performance, Maintenance** – Security often conflicts directly with usability, performance, and maintainability. We need to strike the right balance.

Warning: Tradeoffs



Design Principles

9. **Auditing and logging** – Logging helps to battle insider threats and is key for compliance.
10. **Choose components based on functionality *and* security** – Applications are collections of individual components. Choices of components need to factor in security.

Design Principles

11. **Don't make security assumptions about other people's code** – Operating system libraries, 3rd party code, and modules developed internally don't often do what you assume.
12. **Identify behavioral impact of security controls** – Adding security controls has to be tempered by how users will react to them.

Design Principles

13. **Compliance: Attackers may attack you, auditors will show up** – Designing "secure" software is as much about compliance requirements as it is about actual security.
14. **Threat Analysis and Modeling** – Threat modeling is the process of thinking like attackers and can help identify risks and prioritize application security efforts.
15. **Tunable security levels** – Software needs to accommodate a range of users with varying security needs.
16. **Don't assume data integrity** – We need to ensure that when an application trusts data or code that the trust is warranted.

Design Principles

17. **Least exposure** – Where possible, designers need to minimize the attack surface of their software.
18. **Secure by default** – Most users accept defaults; we need to ensure that software behaves securely out of the box.
19. **Don't reinvent the wheel** – Creating your own encryption algorithm or even your own implementation of complicated security code is often a bad idea.
20. **Beware legacy code and backward compatibility** – We need to ensure that backward compatibility balances with security and doesn't weaken the system.

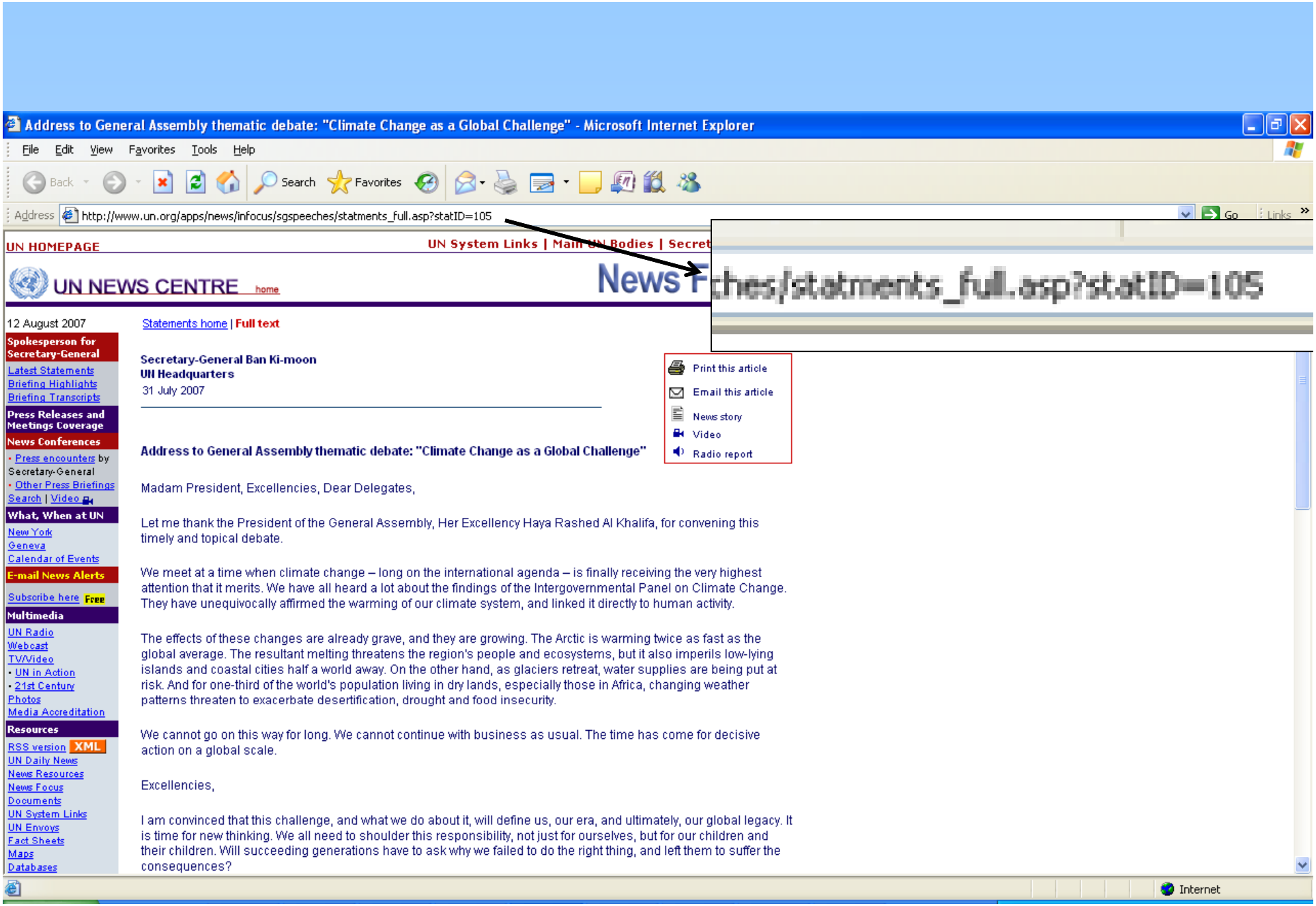
Design Principles

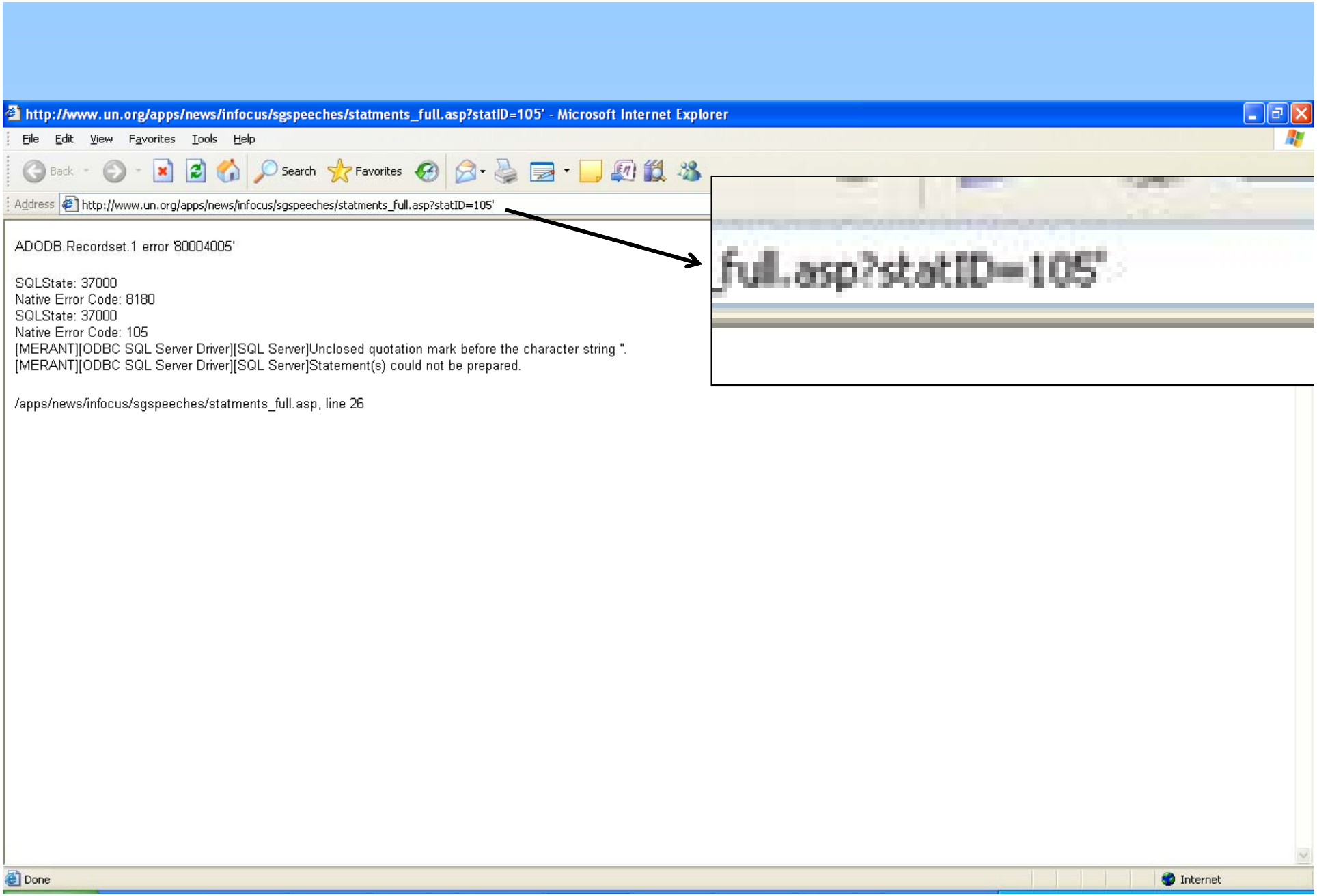
21. **Secure the weakest link** – Software is only as secure as its weakest link.
22. **Secure all access routes** – We need to consider all access routes to sensitive data or functionality.
23. **Security through obscurity doesn't work** – We need to assume that attackers have full knowledge of the code and design.
24. **Beware of shared resources** – Memory, disk space, and network bandwidth are usually shared resources. We need to make sure an attacker can't control them to compromise security.

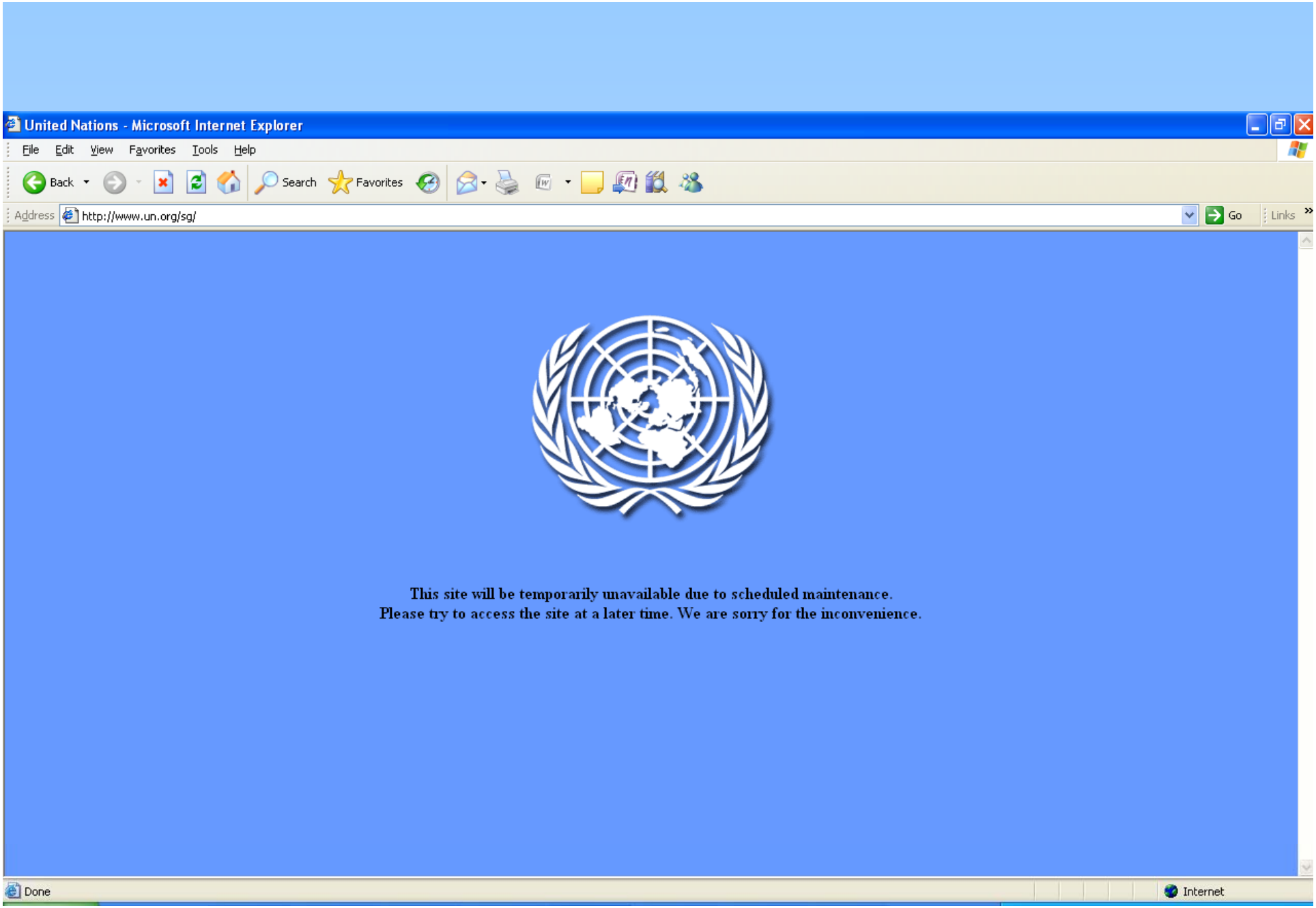
Design Principles

25. **Learn from mistakes** – There is no better security lesson than to thoughtfully go through the vulnerabilities reported in similar projects or designs.

Input Validation



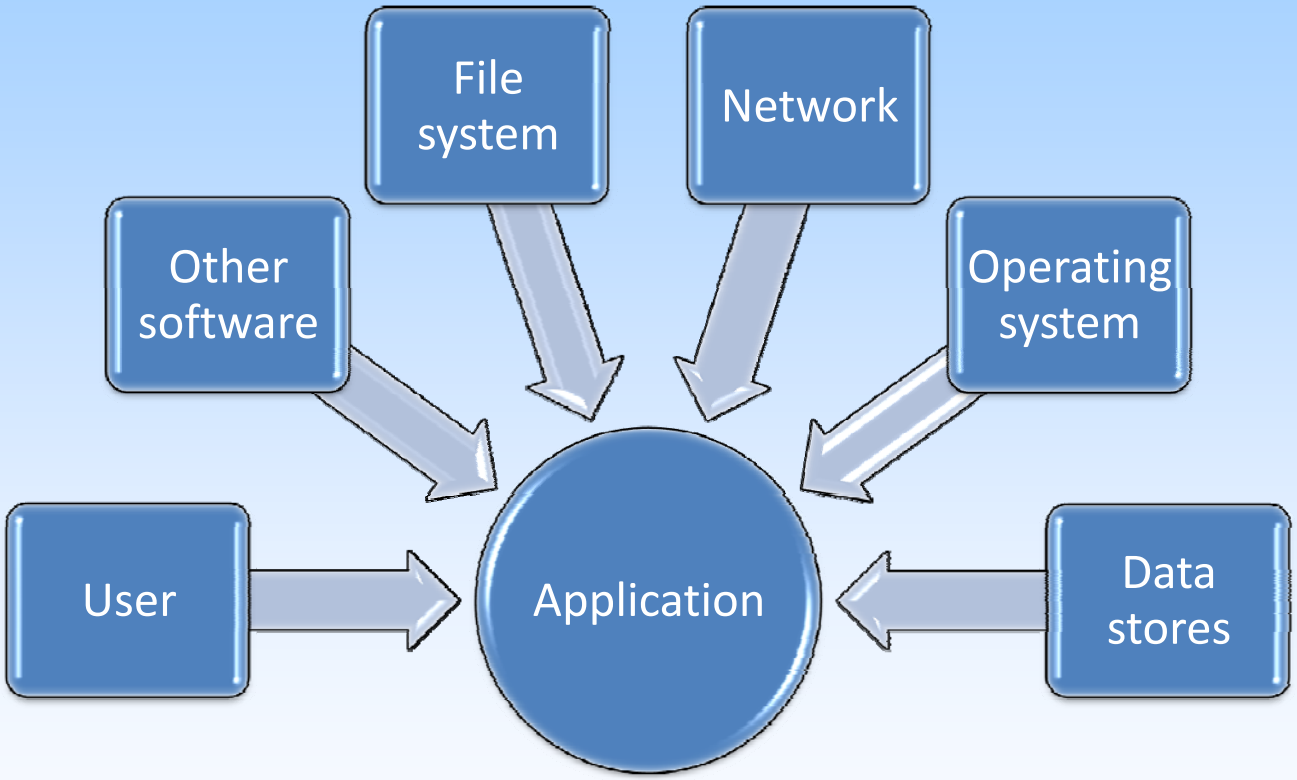




Beware the dreaded INPUT

- Many of the most severe vulnerabilities in software come from a failure to properly constrain input:
  - Buffer overflows, SQL Injection, format string, vulnerabilities, cross site scripting…
- As developers, we need to:
  - Identify assumptions we are making about input
  - Understand what input can be harmful
  - Constrain input appropriately

Think broadly about input…



Solution Strategies

- Regular expressions
  - Allow you to define *what is correct* as opposed to *what is incorrect* (especially important given canonicalization)
- Set input "gates" to filter/constrain input and then define a trust boundary
  - This helps you to maintain performance by assuming that data has been sanitized
  - Ensure that gates consider special characters, canonicalization, and 2nd order attacks

Public enemy number 1 (...sort of)

Vulnerability	% of all vulnerabilities
Cross-site scripting (aka XSS)	13.80%
Buffer overflows	12.60%
SQL injection	9.30%
PHP remote file inclusion	5.70%
Directory traversal	4.70%
Information leakage	3.40%
Denial of Service by malformed input	2.80%
Symbolic link following	1.80%
Format string vulnerability	1.70%
Cryptographic error	1.50%

*SOURCE: MITRE and CVE

Buffer Overflows: Dangerous Functions

- Buffer overflows are the number one vulnerability reported in C/C++ software (by a significant margin!)
- They occur when we make assumptions about input length but don't enforce them
- Top offenders (these don't consider destination buffer size):
  - strcpy(), strcat(), sprintf(), gets(), scanf(), sscanf(), fscanf()

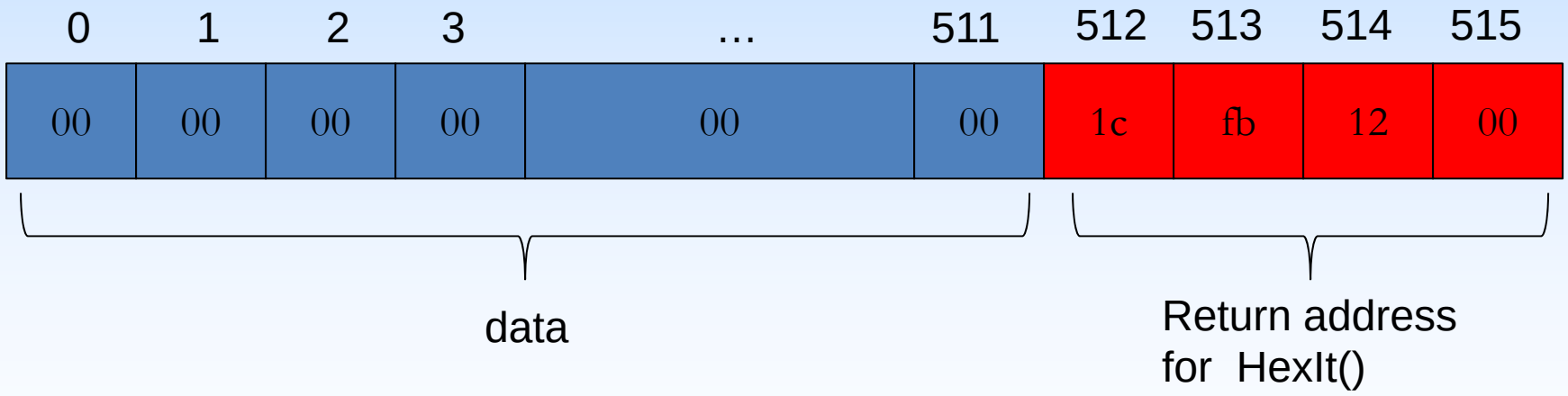
```
int main(int argc, char* argv[]){
//some code
FILE* fp = fopen(fileName, "rb");
int len;
//file checking code
HexIt(fp);
//other code
}

Void HexIt(FILE* file)
{
  int len;
  unsigned char data[512]; //Buffer to hold data
  FILE* fp = file;
  fseek(fp, 0, SEEK_END);
  len = ftell(fp);
  fseek(fp, 0, SEEK_SET);
  fread(data, 1, len, fp); //reads the file data
  fclose(fp);
  PrintHex(data, len); //function to output the data
}
```

The Stack

```
void HexIt(FILE* file)
{
        unsigned char data[512];
}
```

data[*n*]



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