INF 102
CONCEPTS OF PROG. LANGS
ADVERSITY

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Approaches to failure

- Let it fail
  - Good in development: understand failure mode
- Defend against the possible and the impossible
  - Good in production. Detect and…
    - Correct?
    - Ignore?
    - Report?
    - Pass up?
    - Stop?
- Prevent
  - Ideal(ist)

Obliviousness

- Failure is an option!
  - Especially when you learn from it to avoid it in the future
- Obliviousness exposes problems
  - Better than hiding them
  - Shows you failure conditions you might not have considered
- Fix as you go, during development
- Avoid in production

Defensive

- Detect every possible failure

- Paranoid: detect unlikely failures too

Reaction to failures

- Detect and correct (constructivist)
- Detect and ignore (lazy)
- Detect and report (tantrum)
- Detect and pass up the stack (passive-aggressive)

- Recover vs. Stop immediately

Overreaction is bad

```
Integer one = 1;
Integer two = one + one;

if (two > one) {
    ...do stuff...
}
```

Overreaction is bad

```
public class Person {
    private String name = null;

    public void setName(String name) { this.name = name; }

    public String getName() {  return name;     }
}

public Person newPerson(String name) {
    Person person = new Person();
    if (name != null) {
        person.setName(name);
    }
    return person;
}
```

Lazyness is bad

```
void addFriendToList(List<Friend> friends, Friend newFriend) {
    if (friends != null && newFriend != null) {
        friends.add(newFriend);
    }
}
```

bad

```
void addFriendToList(List<Friend> friends, Friend newFriend) {
    friends.add(newFriend);
}
```

better

```
void addFriendToList(List<Friend> friends, Friend newFriend) {
    if (friends != null && newFriend != null) {
        friends.add(newFriend);
    }
    else throw new Exception(“...”);
}
```

better

Lazyness is bad

```
public List<Friend> findFavoriteFriends(Person person) {
    List<Friend> favoriteFriends = new ArrayList<Friend>();

    if (person != null) {
        List<Friend> friends = person.getFriends();

        if (friends != null) {
            for (Friend friend : friends) {
                if (friend != null) {
                    if (friend.isFavorite()) {
                        favoriteFriends.add(friend);
                    }
                }
            }
        }
    }

    return favoriteFriends;
}
```

bad

Spectrum of reactions

- Recover: do you have a good guess for reasonable state?
- Report & proceed
- Pass up
- Fail fast: avoid corruptions by stopping immediately after a failure occurs

Recover (i.e., constructionist style)

```
public class Person {
    private String name = “Unknown User”;

    public void setName(String name) { this.name = name; }

    public String getName() {  return name;     }
}

public Person(String name) {
    if (name != null) {
       person.setName(name);
    }
    // otherwise, use default
    return person;
}
```

Report & Proceed (constructionist++)

```
public class Person {
    private String name = “Unknown User”;

    public void setName(String name) { this.name = name; }

    public String getName() {  return name;     }
}

public Person(String name) {
    if (name == null) {
       log.Warn(“Person constructor given null name arg”);
    }
    person.setName(name);
    // otherwise, use default
    return person;
}
```

Pass up (passive aggressive style)

```
public class Person {
    private String name = “Unknown User”;

    public void setName(String name) { this.name = name; }

    public String getName() {  return name;     }
}

public Person(String name) {
    if (name == null) {
       raise new Exception(“null name”);
    }
    person.setName(name);
    // otherwise, use default
    return person;
}
```

Fail fast (i.e., tantrum style)

```
public class Person {
    private String name = “Unknown User”;

    public void setName(String name) { this.name = name; }

    public String getName() {  return name;     }
}

public Person(String name) {
    if (name == null) {
       log.Warn(“Person constructor given null name arg”);
       System.exit(1);
    }
    person.setName(name);
    // otherwise, use default
    return person;
}
```

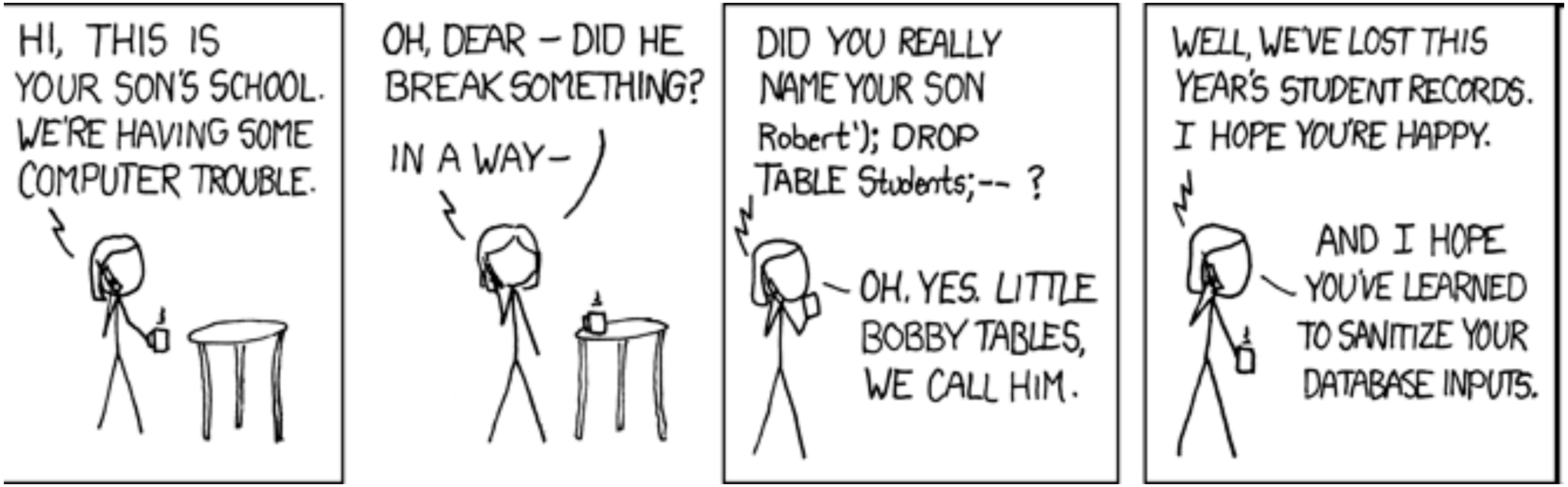
Preventing failures

- Before the program runs:
  - Quarantine vulnerable code
  - Type checking (next lecture)
  - Test (won’t be covered in this course — take INF115)

Vulnerable code

- Anything that deals with IO
  - From users
  - From network
  - From database

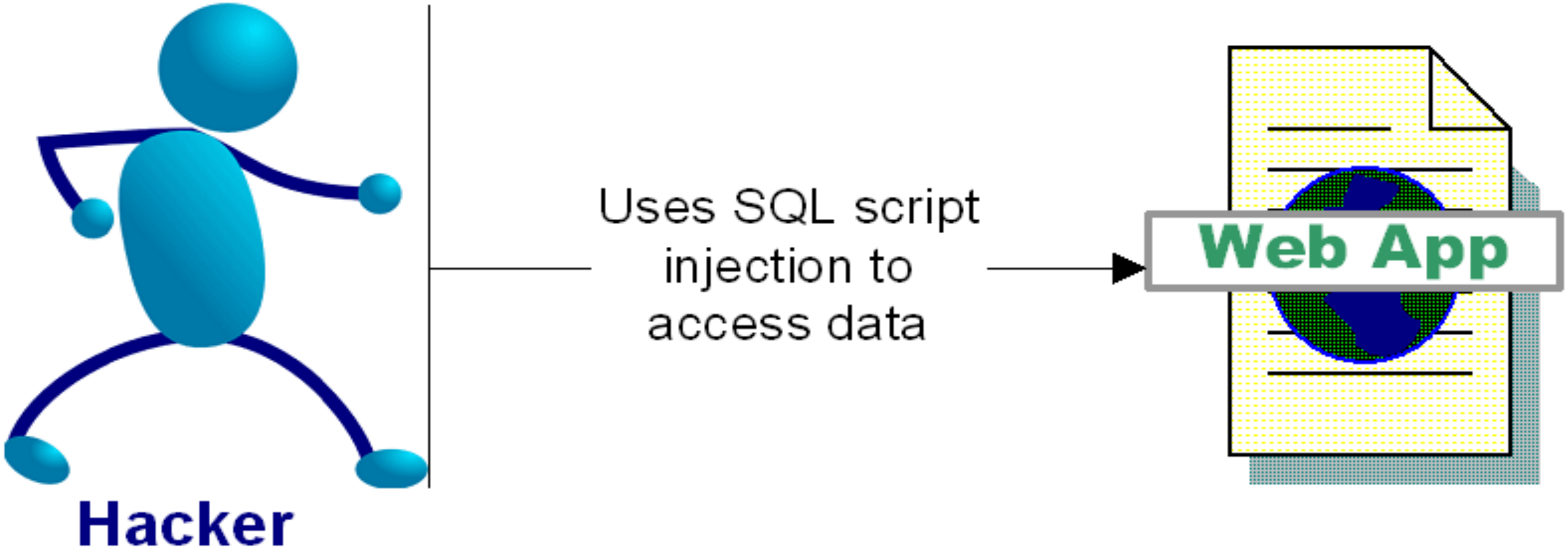
xkcd: “Exploits of a Mom”


HI, THIS IS YOUR SON'S SCHOOL. WE'RE HAVING SOME COMPUTER TROUBLE.
OH, DEAR – DID HE BREAK SOMETHING?
IN A WAY–
DID YOU REALLY NAME YOUR SON Robert'); DROP TABLE Students;-- ?
OH. YES. LITTLE BOBBY TABLES, WE CALL HIM.
WELL, WE'VE LOST THIS YEAR'S STUDENT RECORDS. I HOPE YOU'RE HAPPY.
AND I HOPE YOU'VE LEARNED TO SANITIZE YOUR DATABASE INPUTS.

http://xkcd.com/327/

SQL Injection Attacks

“**SQL injection** is a security vulnerability that occurs in the database layer of an application. Its source is the incorrect escaping of dynamically-generated string literals embedded in SQL statements. “ (Wikipedia)



Uses SQL script injection to access data

Impact of SQL Injection - Dangerous

- At best: you can leak information
- Depending on your configuration, a hacker can
  - Delete, alter or create data
  - Grant direct access to the hacker
  - Escalate privileges and even take over the OS

SQL Injection Attacks

- Login Example Attack
  - Text in blue is your SQL code, Text in orange is the hacker input, black text is your application code
  - Login: Password:
- Dynamically Build SQL String performing authentication:
  - “SELECT * FROM users WHERE login = ‘” + userName + “‘ and password= ‘” + password + “‘”;
- Hacker logs in as: **‘ or ‘’ = ‘’; --**
  - SELECT * FROM users WHERE login = ‘’ **or ‘’ = ‘’; --**‘ and password=‘’

More Dangerous SQL Injection Attacks

- Hacker creates a Windows Account:
  - SELECT * FROM users WHERE login = ‘**’; exec master..xp_cmdshell 'net users username password /add';--**’ and password= ”
- And then adds himself as an administrator:
  - SELECT * FROM users WHERE login = ‘**’; exec master..xp_cmdshell 'net localgroup Administrators username /add';--**’ and password= ‘’
- SQL Injection examples are outlined in:
  - http://www.spidynamics.com/papers/SQLInjectionWhitePaper.pdf
  - http://www.unixwiz.net/techtips/sql-injection.html

Preventing SQL injection

- Use Prepared Statements (aka Parameterized Queries)

  -
    ```
    PreparedStatement stmt = conn.createStatement("INSERT INTO
    students VALUES('" + user + "')");
    stmt.execute();
    ```

    bad

vs

  -
    ```
    PreparedStatement stmt = conn.prepareStatement("INSERT
    INTO student VALUES(?)");
    stmt.setString(1, user);
    stmt.execute();
    ```

    better

Consider if user is “`Robert'); DROP TABLE students; --`”

- Validate input
  - Strong typing
    - If the id parameter is a number, try parsing it into an integer
  - Business logic validation
- Escape questionable characters (ticks, --, semi-colon, brackets, etc.)

More than SQL

- "Injection Flaw" is a blanket term
- SQL Injection is most prevalent
- Other forms:
  - XPath Injection
  - Command Injection
  - LDAP (Lightweight Directory Access Protocol) Injection
  - DOM (Document Object Model) Injection
  - JSON (Javascript Object Notation) Injection
  - Log Spoofing
  - On and on and on…

IO Monad

- A explicit reminder that you can’t trust IO
- “Promote” IO-bound functions to higher-order
  - They don’t run until you make an effort