Techniques to Detect License Violations of Open-Source Systems

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The Cisco case

CISCO SYSTEMS ®

Offshore Development Organization → Broadcom → Linksys → Cisco

Pillory `http://gpl-violations.org/`

How short is a copyright violation?

Question

How short may a copy be to be still considered a violation?

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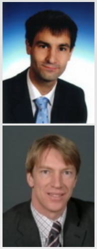
Answer

54 LOC (out of 160 KLOC) may be sufficient if they are essential for the operation of a program.

– American Court (Mertzel, 2008)

Questionnaire among more than 100 developers



- copying of open-source software (OSS) by commercial companies is frequent
- developers are lacking understanding of the legal risks
- organizations are lacking policies for OSS use

— Sojer und Henkel (2010)

Audits of OSS use

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$$323 \cdot 2^{20}[\mathrm{LOC}] \cdot 50[\mathrm{characters}/\mathrm{LOC}] \cdot 0.5[\mathrm{cm}/\mathrm{LOC}]$$
$$= 83,860.256[\mathrm{km}]$$

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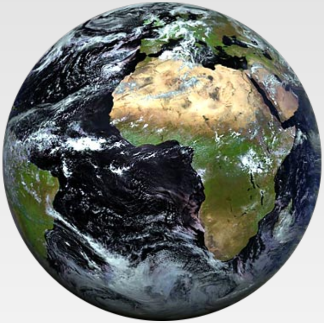

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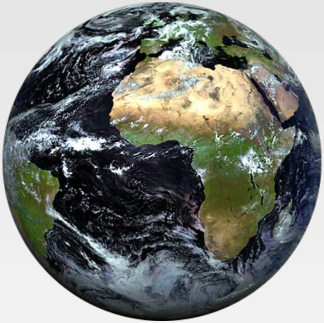
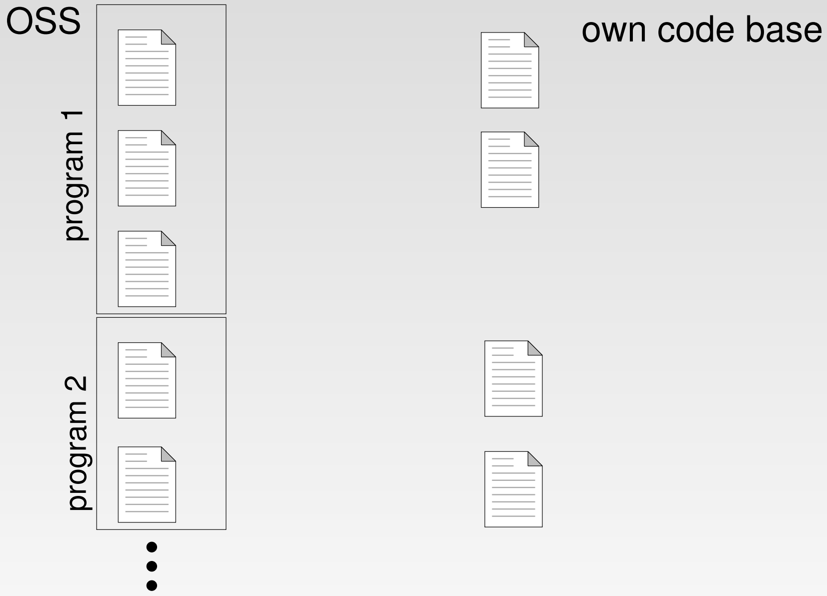


Search for copyright violations



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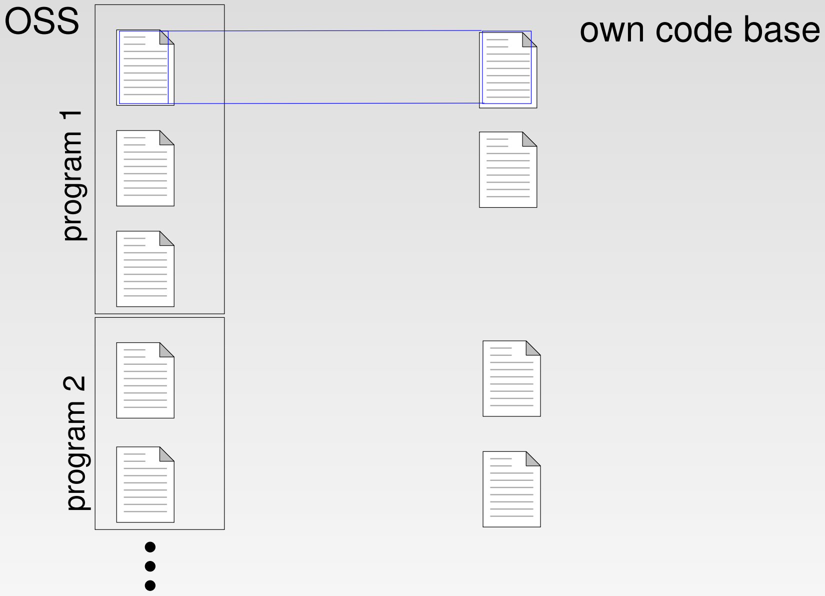

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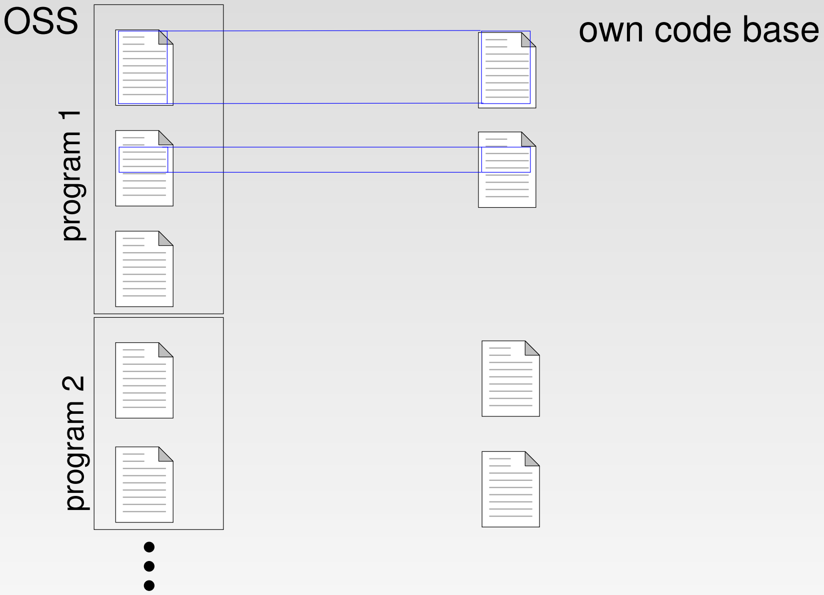

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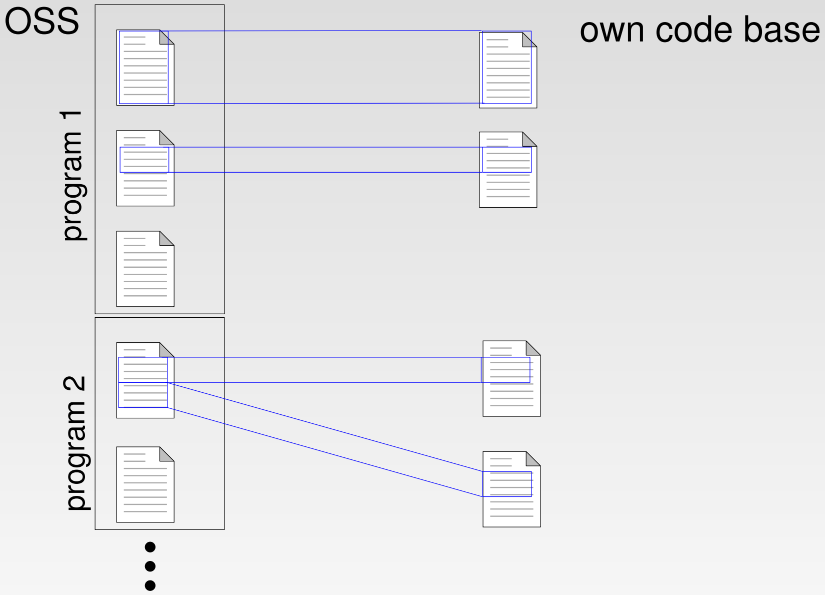

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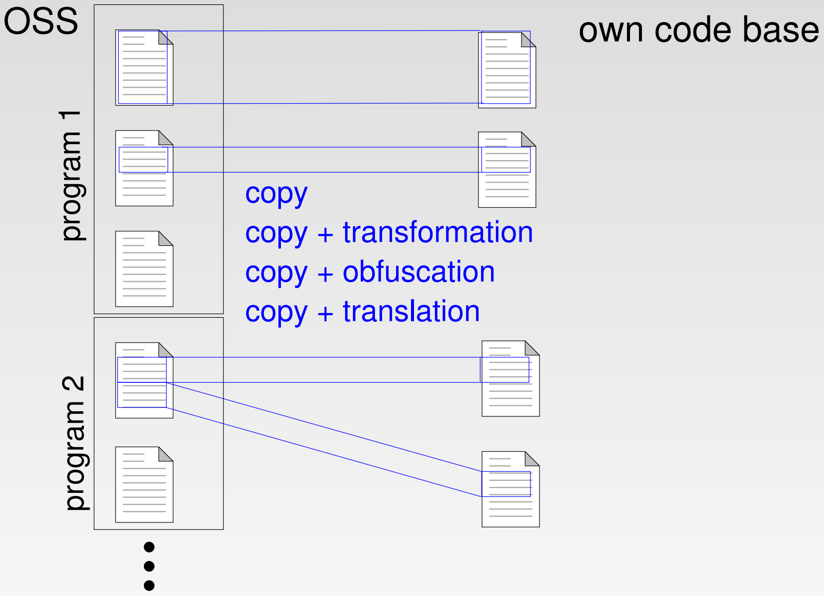

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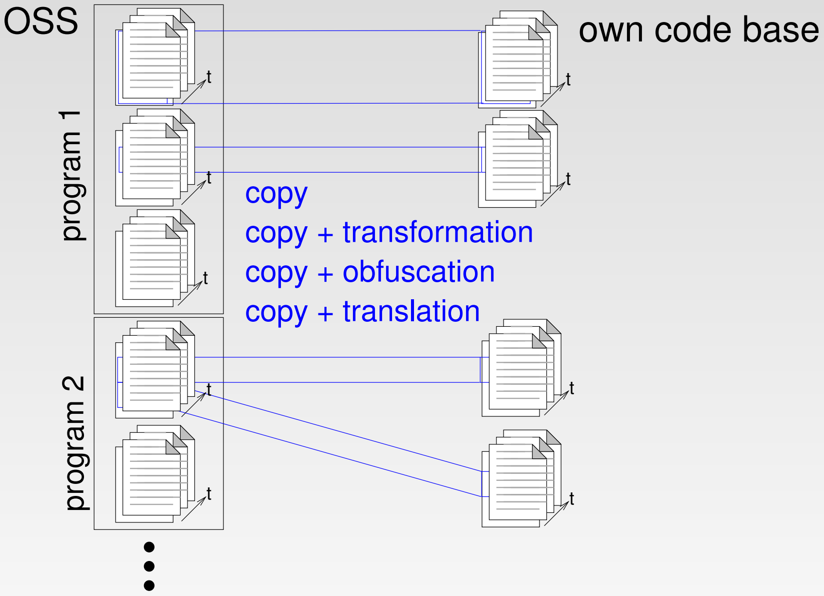


Challenges of copyright violation detection

- Is source code available at all?
- What to compare?
- What granularity (whole files, parts thereof)?
- Degree of tolerance of:
  - transformation
  - obfuscation
  - translation

What to compare?

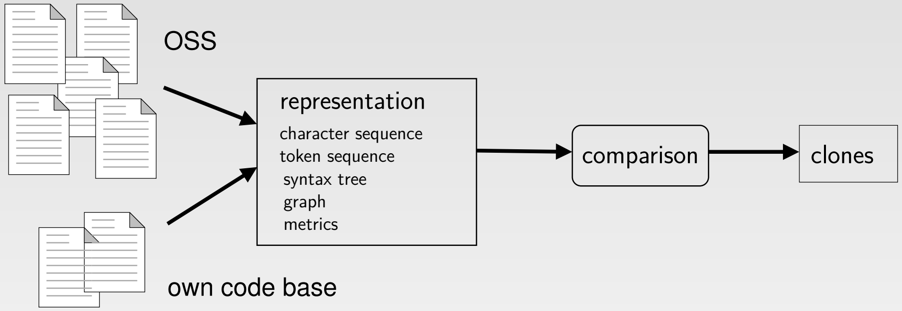
Name	URL
SourceForge	http://sourceforge.net/
freshmeat	http://freshmeat.net/
Debian	http://ftp.debian.org/debian/pool/
Apache Software Foundation	http://apache.org/
CPAN	http://cpan.org/
CRAN	http://cran.r-project.org/
BerliOS Developer	http://developer.berlios.de/
Open Source Scripts	http://opensourcescripts.com/
GNU Savannah	http://savannah.gnu.org/
OpenSymphony	http://www.opensymphony.com/
Koders	http://koders.com/
ObjectWeb	http://objectweb.org/
JBoss	http://jboss.com/
PEAR	http://pear.php.net/
JSAN	http://openjsan.org/
CodePlex	http://www.codeplex.com/
Free Software Directory	http://directory.fsf.org/
Ohloh	http://ohloh.net/
TuxFamily	http://project.tuxfamily.org/
OSOR.eu	http://www.OSOR.eu/
Launchpad	http://www.launchpad.net/
RubyForge	http://rubyforge.org/

— http://en.wikipedia.org/wiki/List_of_free_software_project_directories

Commercial tools

- BitMatch (S.A.F.E.) `http://www.safe-corp.biz/`
  - Comparison of binary files of contained strings
- CodeMatch (S.A.F.E.) `http://www.safe-corp.biz/`
  - Correlation of statements, comments and identifiers in files (Zeidman, 2007, 2008)
- Protex (Black Duck Software), `http://www.blackducksoftware.com/`
  - File comparison via hashing?
- Protecode System 4 (Protecode) `http://www.protecode.com/`
  - File comparison (binary + source) via hashing?
- SIMILE workshop (ESALAB), `http://www.esalab.com/`
  - (Service) Comparison of identifiers, syntax, and semantics (details unknown) in object code

Clone detection



Clone of type 1

Definition

Type 1: Copy without transformation (except reformatting and commenting)

```
int product (int n) {
  int i = 1;
  int result = 1;
  while (i <= n) {
    result = result * i;
    i = i + 1;
  }
  return result;
}
```

```
int product (int n) {
  int i = 1; int result = 1;
  while (i <= n) {
    result=result*i; i=i+1;
  }
  return result;
}
```

Clone of type 2

Definition

Type 2: Copy with parameter substituions (identifiers and literals)

```
int product (int n) {
    int i = 1;
    int result = 1;
    while (i <= n) {
        result = result * i;
        i = i + 1;
    }
    return result;
}
```

```
int prod (int x) {
    int j = 1;
    int r = 1;
    while (j <= x) {
        r = r * j;
        j = j + 1;
    }
    return r;
}
```

product $\rightarrow$ prod, n $\rightarrow$ x, i $\rightarrow$ j, result $\rightarrow$ r

Clone of type 3

Definition

Type 3: Copy with additional/deleted/modified statements/expressions

```
int product (int n) {
  int i = 1;
  int result = 1;
  while (i <= n) {
    result = result * i;
    i = i + 1;
  }
  return result;
}
```

```
int compute (int n, int &sum) {
  int i = 1;
  int result = 1;
  sum = 0;
  while (i <= n) {
    result = result * i;
    sum = sum + i;
    i = i + 1;
  }
  return result;
}
```

Syntactic obfuscation

Definition

Obfuscation: semantic-preserving and syntax-mutating transformations

```
int product (int n) {
  int i = 1;
  int result = 1;
  while (i <= n) {
    result = result * i;
    i = i + 1;
  }
  return result;
}
```

```
int prod (int x) {
  int r = 1;
  for (int j = 0; j < x; j++)
    r = r * (j+1);
  return r;
}
```

Cross-language clones

Definition

Cross-language clones: translation to different programming language

```
int product (int n) {
  int i = 1;
  int result = 1;
  while (i <= n) {
    result = result * i;
    i = i + 1;
  }
  return result;
}
```

```
function product (n : natural)
             return natural
is
  result : natural := 1;
begin
  for i in 1 .. n loop
    result := result * i;
  end loop;
  return result;
end product;
```

Modification tolerance

Comparison of source code with tolerance against transformation/obfuscation/translation

Rep.	Transf./Obfusc.	Translation
Text	—	—
Tokens	token normalization	shared token vocabulary
Syntax	syntactic normalization	unified syntax trees
PDG	reduction to data/control dep.	similar data/control dep.

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Indirect comparison: comparing the compilation (ByteCode, Microsoft IL, object code)

Summary

- Copyright violation is a relevant problem with bad consequences
- Clone detection techniques may help, they vary in . . .
    - scalability
    - granularity
    - modification tolerance

Summary

- Copyright violation is a relevant problem with bad consequences
- Clone detection techniques may help, they vary in . . .
  - scalability
  - granularity
  - modification tolerance
- Clone detection techniques must be adjusted
- Tools can find only evidence, no proof
- Tools are at least a *best effort*

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