Analysis of the Linux Kernel Evolution Using Code Clone Coverage

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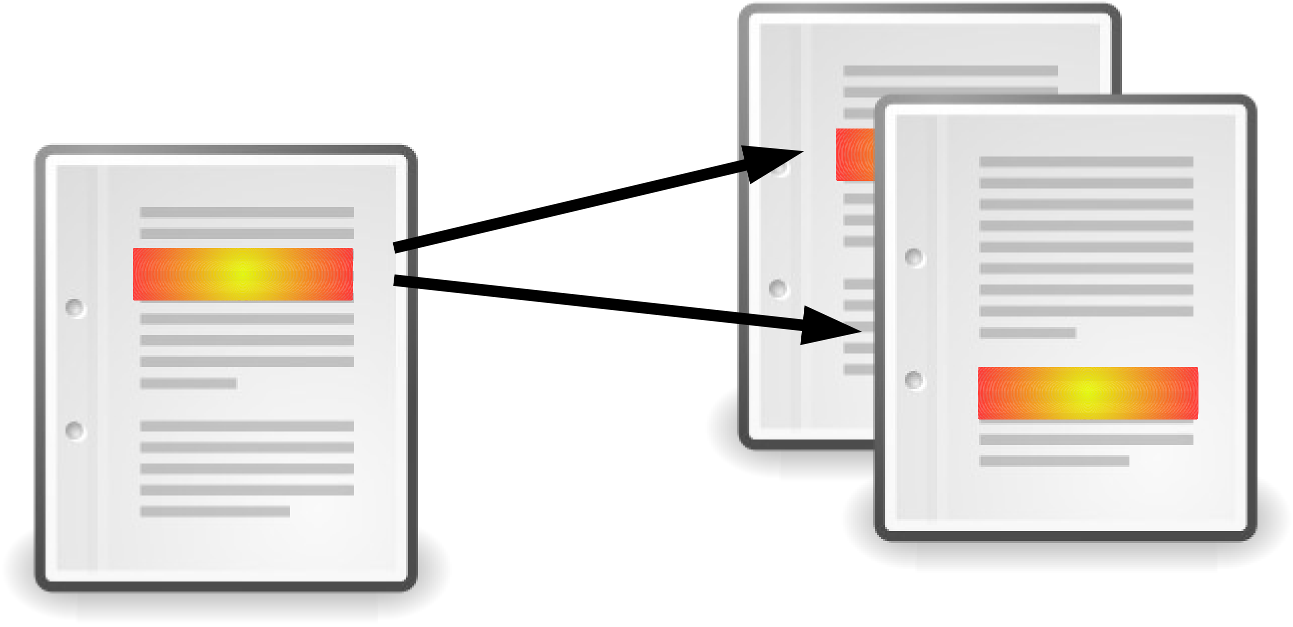
Code clone?

Code Clone?

- A code clone is a set of identical or similar fragments of code



Code Clone Detection

- Various detection methods
  - Token based
  - Abstract Syntax Tree based
  - Program Dependence Graph based
  - …

CCFinder

- Token-based code-clone detection tool
  - Insensitive to renamed variable and code layout
  - Multi language support (C, C++, COBOL, Java, ...)
- Very good scalability and speed...

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- Very good scalability and speed...
- ...but scalability is limited by the hardware used

D-CCFinder

- A system for distributed code clone analysis
- Uses CCFinder as code clone detector

What?

What

Start a large scale study of a software system's evolution using code clone analysis

Why?

Why

- The evolution of a software system can be reconstructed with code clone analysis
- No large scale study have been performed yet
- D-CCFinder permits large scale code clone analysis

Why

- The evolution of a software system can be reconstructed with code clone analysis
- No large scale study have been performed yet
- D-CCFinder permits large scale code clone analysis
- There were two weeks left before the deadline and we had nothing to do

The guinea pig

The Linux Kernel

- 15 years long development effort involving hundreds of developers
- Two development branches: **stable** and **unstable** (prior to version 2.6)
- The source code size grew from 3.8Mbytes (version 1.0) to 157Mbytes (2.6.18.3)

The Linux Kernel

Version	LOC	Size (Kbytes)	# of versions
1.0	141K	3,926	1
1.2.0~ 1.2.13	234K 238K	6,534 6,596	14
2.0.0~ 2.0.40	563K 768K	16,076 21,952	41
2.2.0~ 2.2.26	1,310K 1,970K	37,056 58,812	27
2.4.0~ 2.4.33.4	2,366K 3,865K	69,200 112,148	34
2.6.0~ 2.6.18.3	4,120K 5,476K	120,030 157,290	19

Total number of versions	136
Number of .c files	376,596
Total lines of code	266,943,565
Total size	7.4 Gbytes

- 136 kernel versions from the stable branches
- Considered only .c files
- Size measured with `du`
- LOC counted with `wc`

How?

How

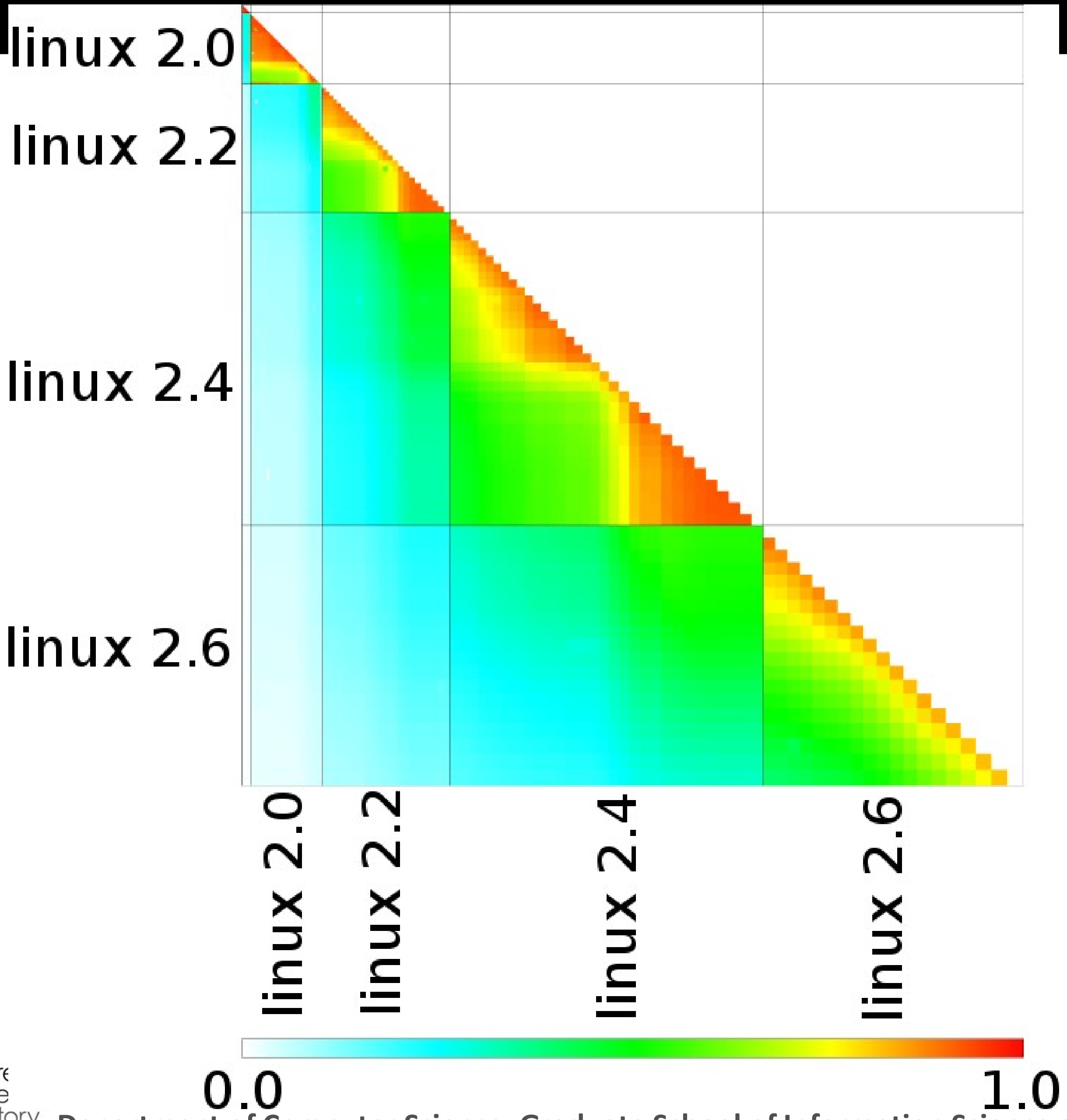
- For each pair (A, B) of kernel versions we computed and plotted the code clone coverage

$$Coverage(A,B)=\frac{Loc(CC(A,B))}{Loc(A)+Loc(B)}$$

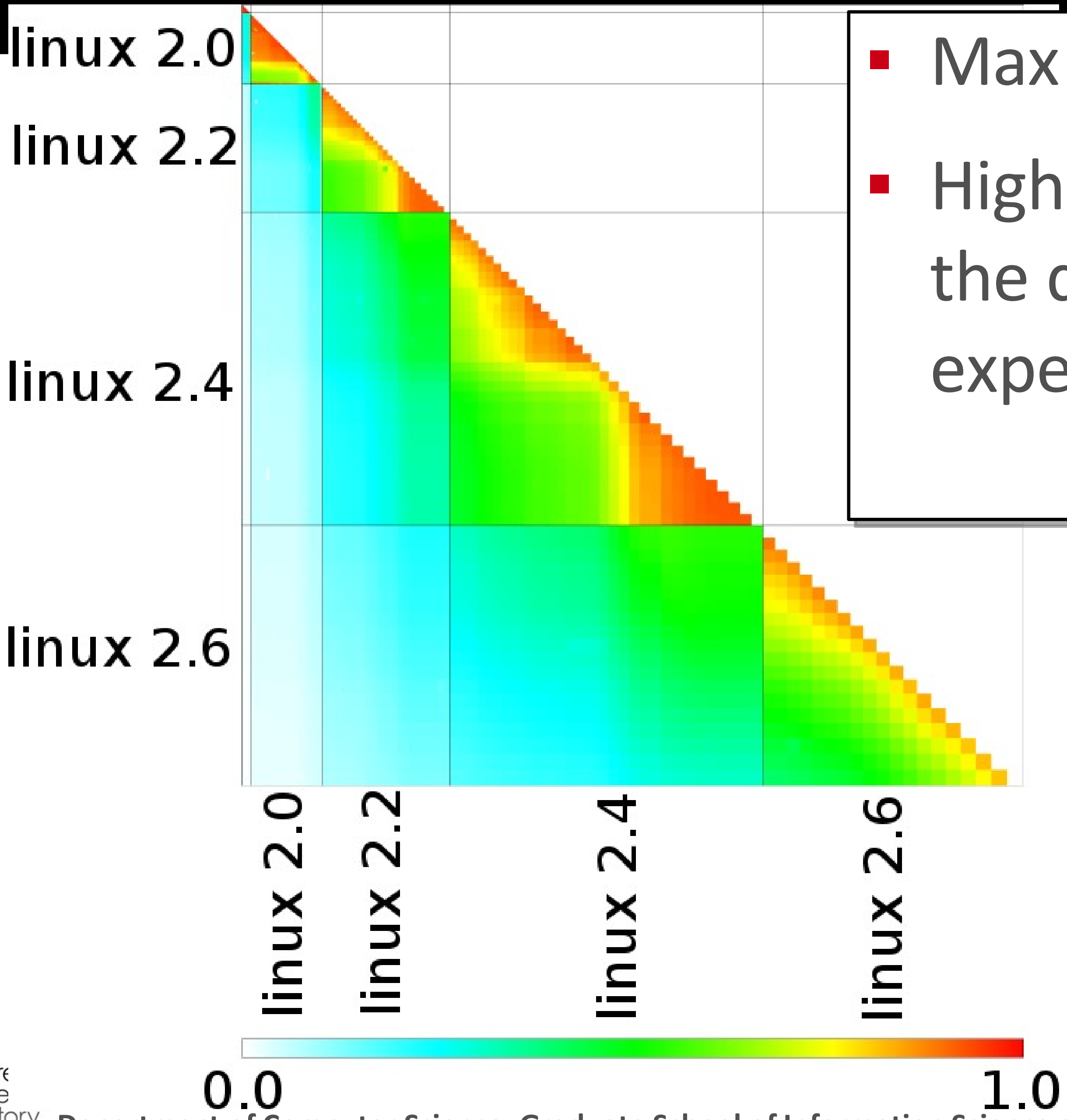
CC(A,B)= code clone fragments between A and B

Results

Results

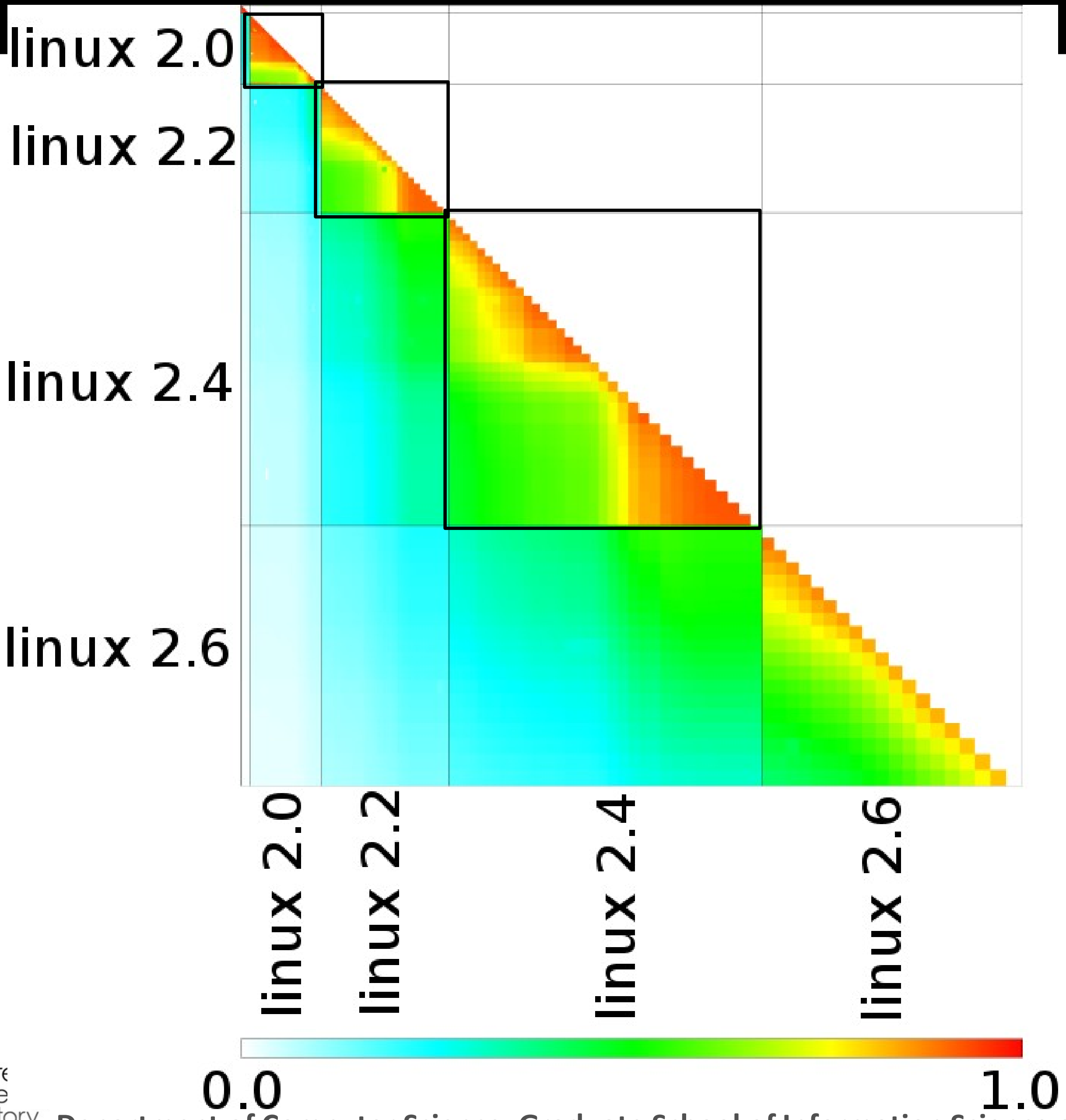

linux 2.0
linux 2.2
linux 2.4
linux 2.6
linux 2.0
linux 2.2
linux 2.4
linux 2.6
0.0
1.0

Results



- Max coverage: 67%
- Highest coverage on the diagonal (as expected)

Results


linux 2.0
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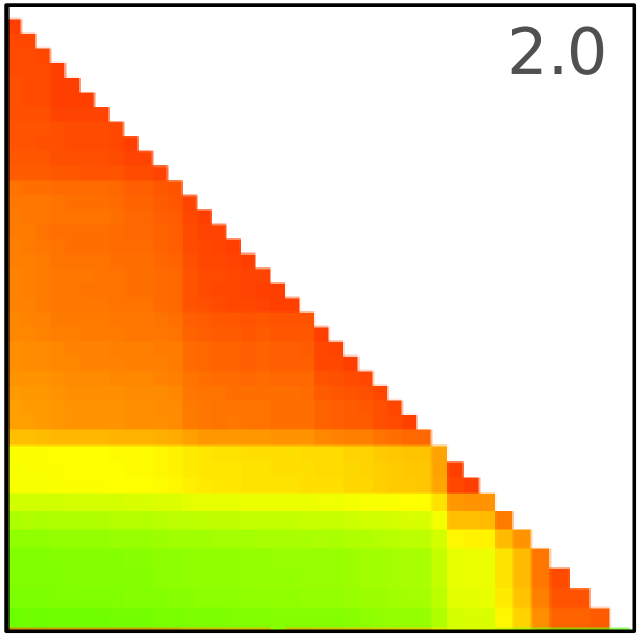
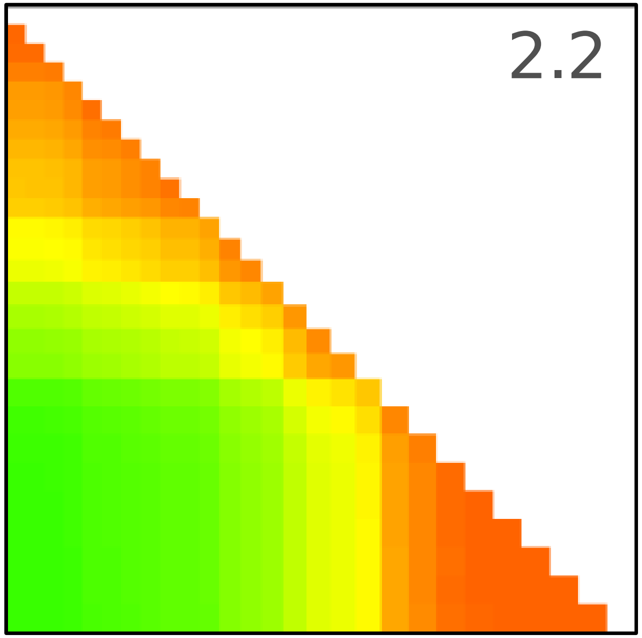
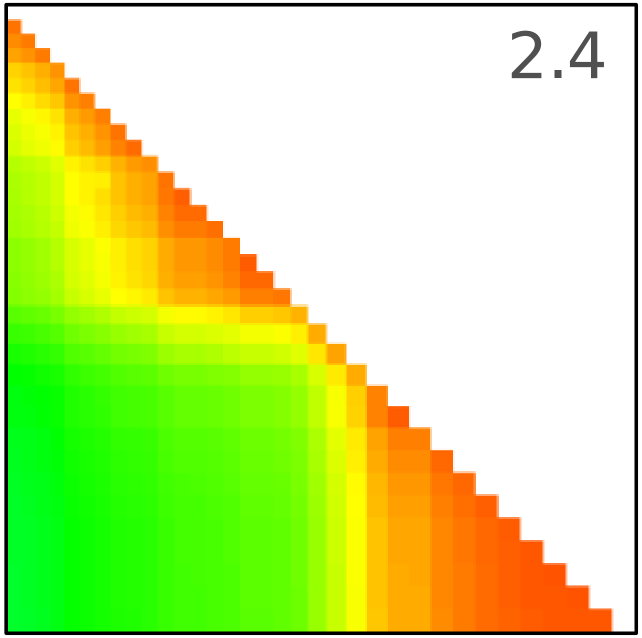
linux 2.6
linux 2.0
linux 2.2
linux 2.4
linux 2.6
0.0
1.0

Results

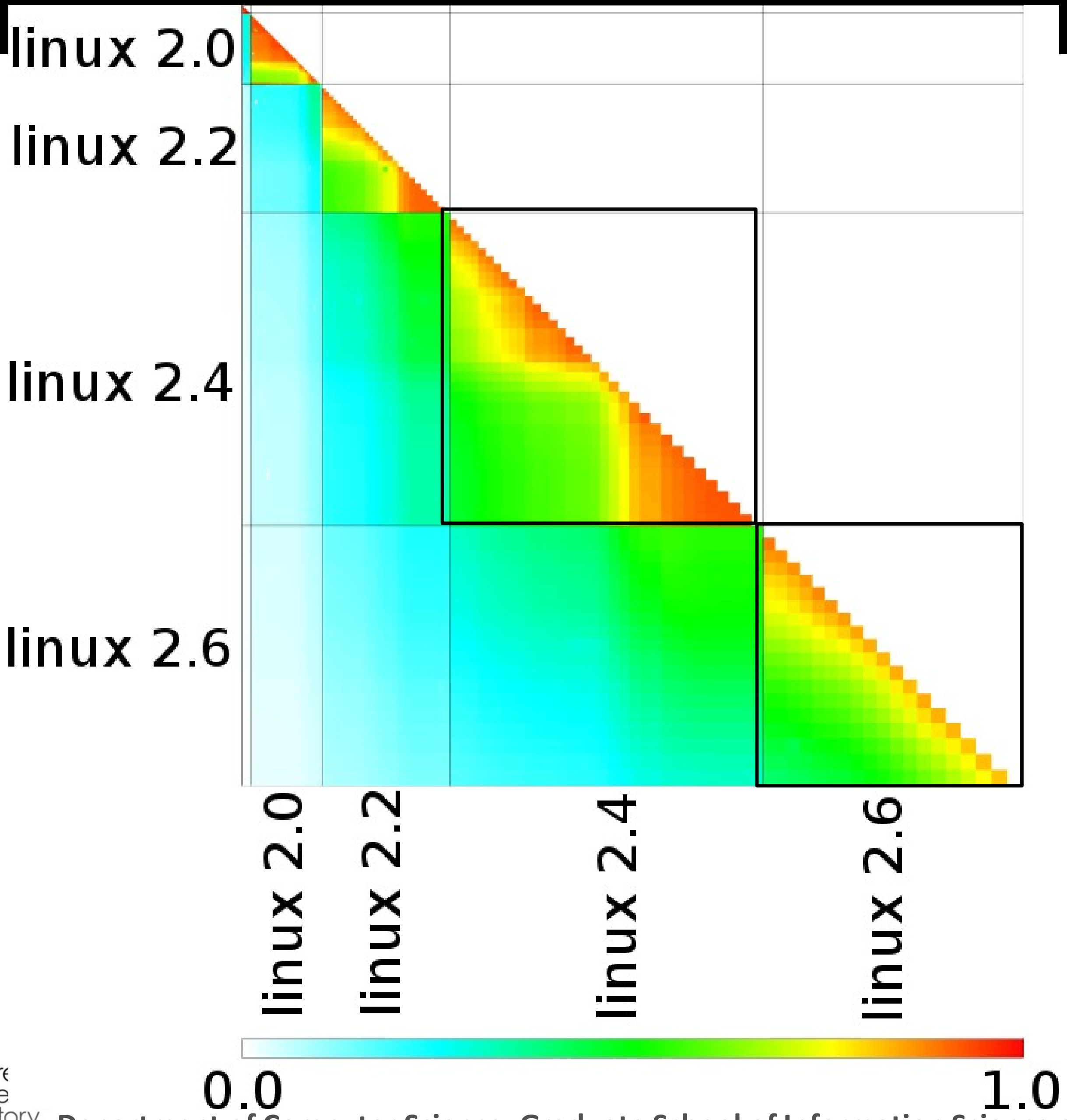
- Same pattern
- Code "back-ported" from the development branches







Results


linux 2.0
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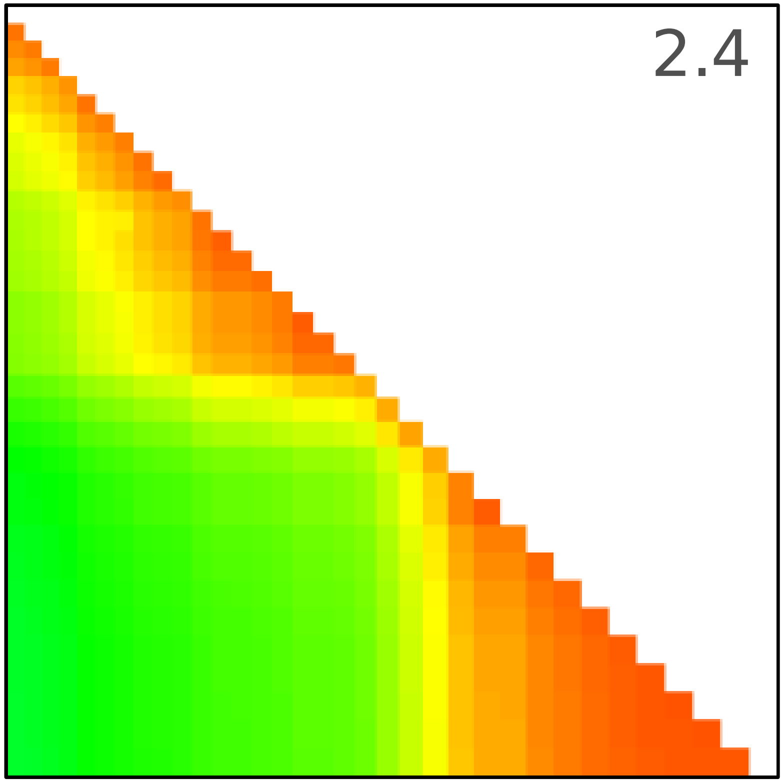
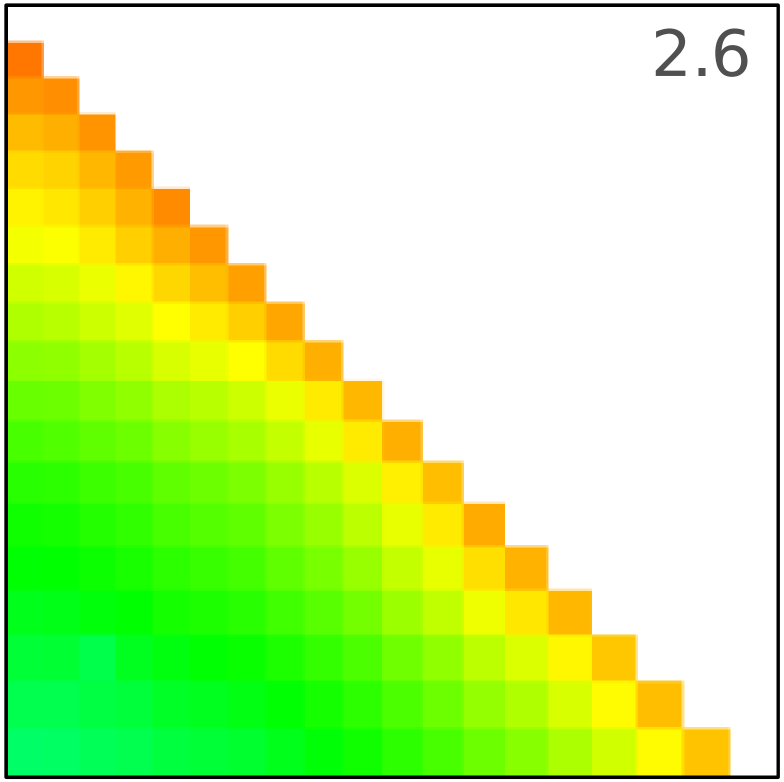
1.0

Results

- Different patterns due to different development processes





Conclusion & Future

- **Conclusion**
  - Presented a tentative study of the evolution of the Linux kernel computing and visualizing the code-clone coverage metric
- **Future**
  - Elaborate and complete the analysis presented and produce a more detailed report of the code changes

以上