LERO Software for a better world

UNIVERSITY OF LIMERICK OLLSCOIL LUIMNIGH

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GLOCC: Giga-line Location of Code Clones

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HUAWEI

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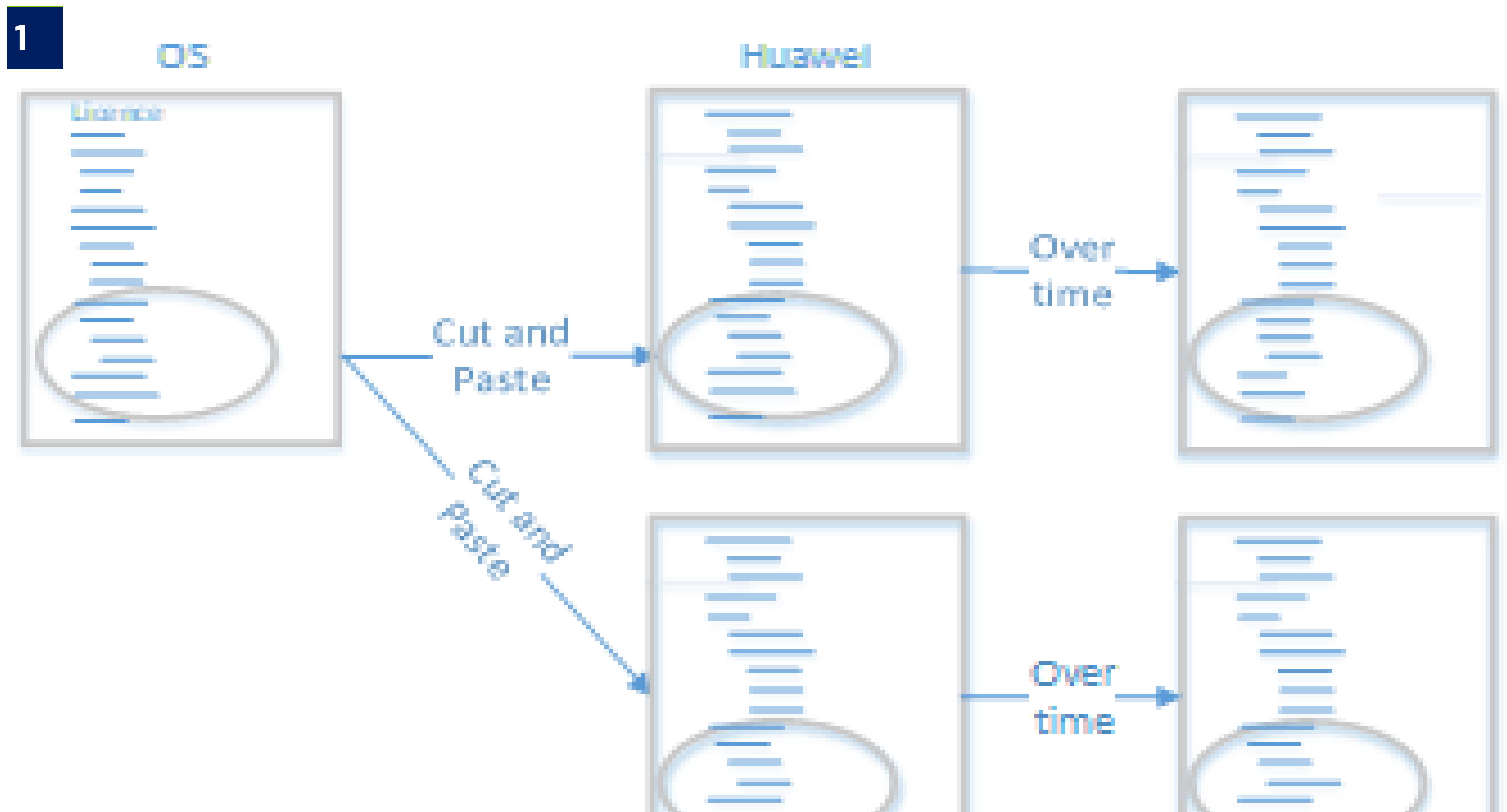

SOFTWARE CLONES:

- Pieces of code that are similar (syntactically or semantically)…
- May be a result of a cut and paste

THE PROBLEM:

- They can cause copyright issues;
- They can cause inherited maintenance issues;
- They can be difficult to find, given that evolve independently (diverge) over time;

THE SOLUTION:

- We need to detect these diverging clones, at 1000MLOC+ scale

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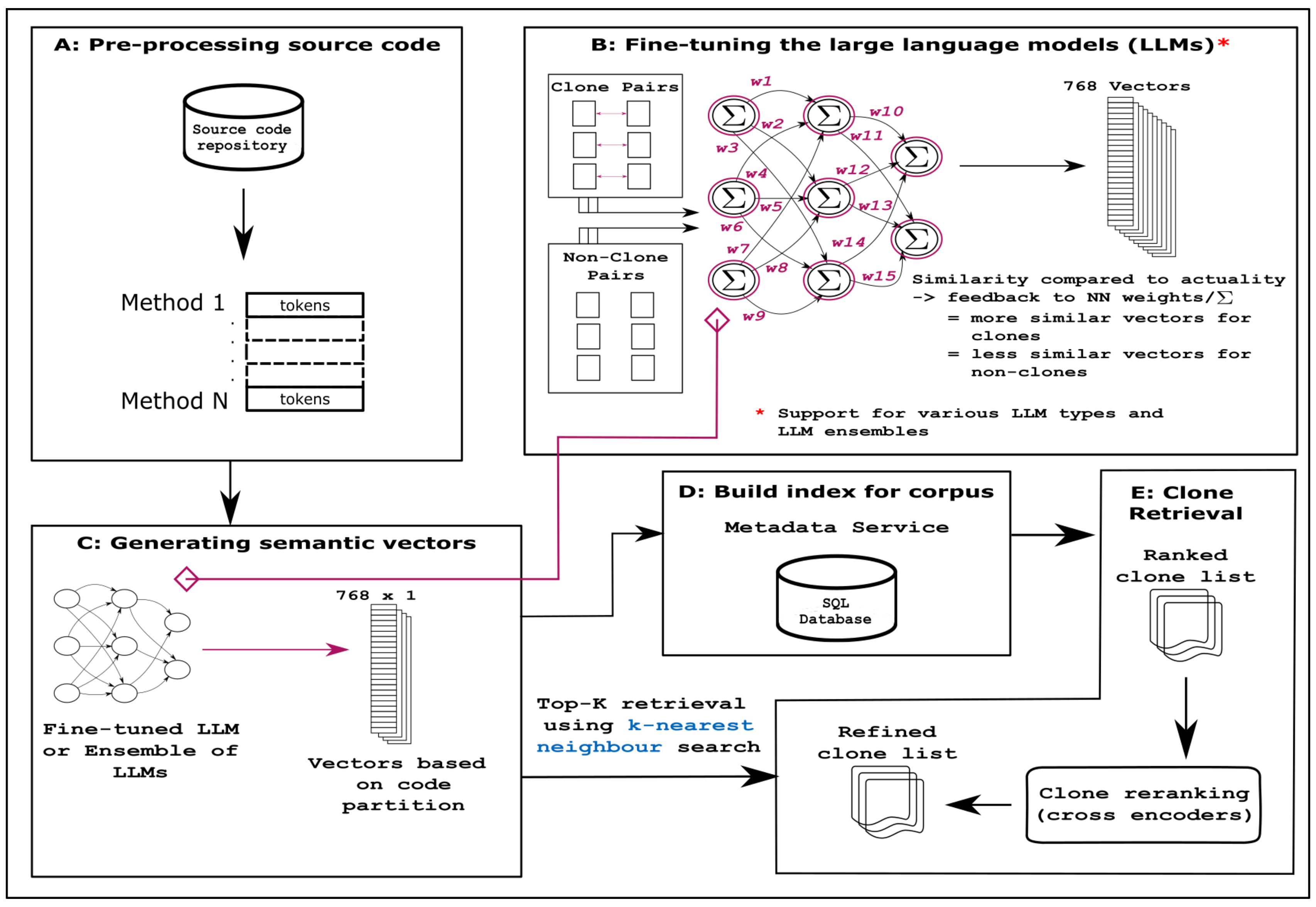
- Approaches for finding Type I/II clones are already quite accurate and quite efficient;
- State-of-the-art NN approaches are showing more promise for Type III/IV clones;
- But they rely on pairwise comparison of code segments and do not scale well as that involves ~O(n^2) comparisons
  - Oreo took nearly 1 day, 21 hours to work its way through the standard benchmark in the field: BCB - 250 MLOC in Java
- We tried a Nearest Neighbour approach.

3 SSCD:


A: Pre-processing source code
Source code repository
Method 1
tokens
Method N
tokens
B: Fine-tuning the large language models (LLMs)*
Clone Pairs
Non-Clone Pairs
w1
w2
w3
w4
w5
w6
w7
w8
w9
w10
w11
w12
w13
w14
w15
768 Vectors
Similarity compared to actuality -> feedback to NN weights/∑
= more similar vectors for clones
= less similar vectors for non-clones
* Support for various LLM types and LLM ensembles
C: Generating semantic vectors
768 x 1
Fine-tuned LLM or Ensemble of LLMs
Vectors based on code partition
D: Build index for corpus
Metadata Service
SQL Database
E: Clone Retrieval
Ranked clone list
Top-K retrieval using k-nearest neighbour search
Refined clone list
Clone reranking (cross encoders)

LLM-encoded vectors, where nearness of vectors reflects code similarity (clones)

4 SSCD, with/without Remove-White-Space/Variable Anonymization Pre-processings, with Active Learning and with state-of-the-art LLMs

Max Recall at a precision of >=0.2 (across a Huawei code-base and 8 OS systems: 362 MLOC):

>=0.2 Precision	Clones Identified by SSCD Variants (and CCFinderX – After filtering)							CCFinderX Totals (after filter)
	Candidates	True clones	Ranked Precision	T1	T2	T3	T4	
SSCD	664	133		18 (15)	14 (14)	98 (14)	3 (2)	45
SSCD (RWS)	1390	279		21 (15)	66 (13)	180 (20)	12 (6)	54
SSCD (RWS + VA)	1496	300		20 (15)	55 (13)	205 (11)	20 (5)	44

Max Recall at a precision of >=0.2 (across the Huawei code-base and the 4 OS systems not used for Active Learning):

>=0.2 Precision	Clones Identified by SSCD Variants (and CCFinderX – After filtering)							CCFinderX Totals (after filter)
	Candidates	True clones	Ranked Precision	T1	T2	T3	T4	
SSCD (RWS)	415	84		4 (3)	28 (4)	47 (6)	5 (2)	15
SSCD (AL)	895	179		4 (3)	43 (11)	121 (6)	11 (4)	24

Preliminary results of trialling newer LLMs on the Huawei-provided Benchmark

Newer LLMs trialled on Huawei's 480KLOC dataset			
LLM	Size (Parameters)	C F-score	C++ F-score
Code T5	220M	85.04	90.45
CodeBERT	125M	77.16	83.33
GraphCodeBERT	125M	80.29	88.31
CuBERT	345M	97.14	95.6
Code T5+	110M	99.29	97.04
SPT-Code	262M	97.84	92.77

- Overall (and in Type 3 particularly), SSCD shows substantial improvement over CCFinderX;
- And pre-processings show further significant improvement;
- Preliminary indications suggest that incorporation of newer LLMs will improve things further.

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