



Automated Software Transplantation

Earl T.
Barr

Mark
Harman

Yue
Jia

**Alexandru
Marginean**

Justyna
Petke

CREST, University College London

Why Automated Transplantation?

~100 players

Check open source repositories

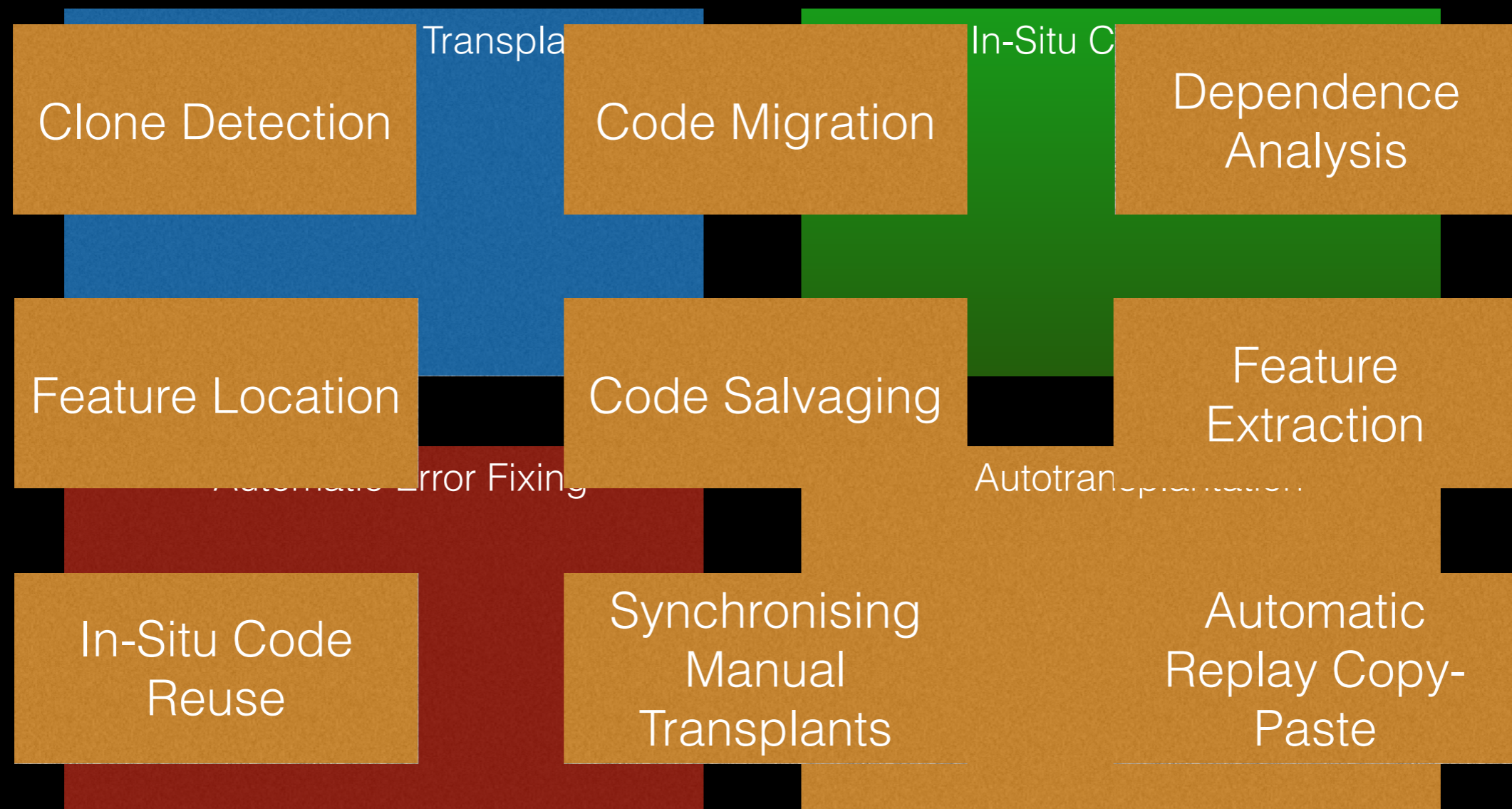
Why not handle H.264?

Video Player

~~Start from scratch~~



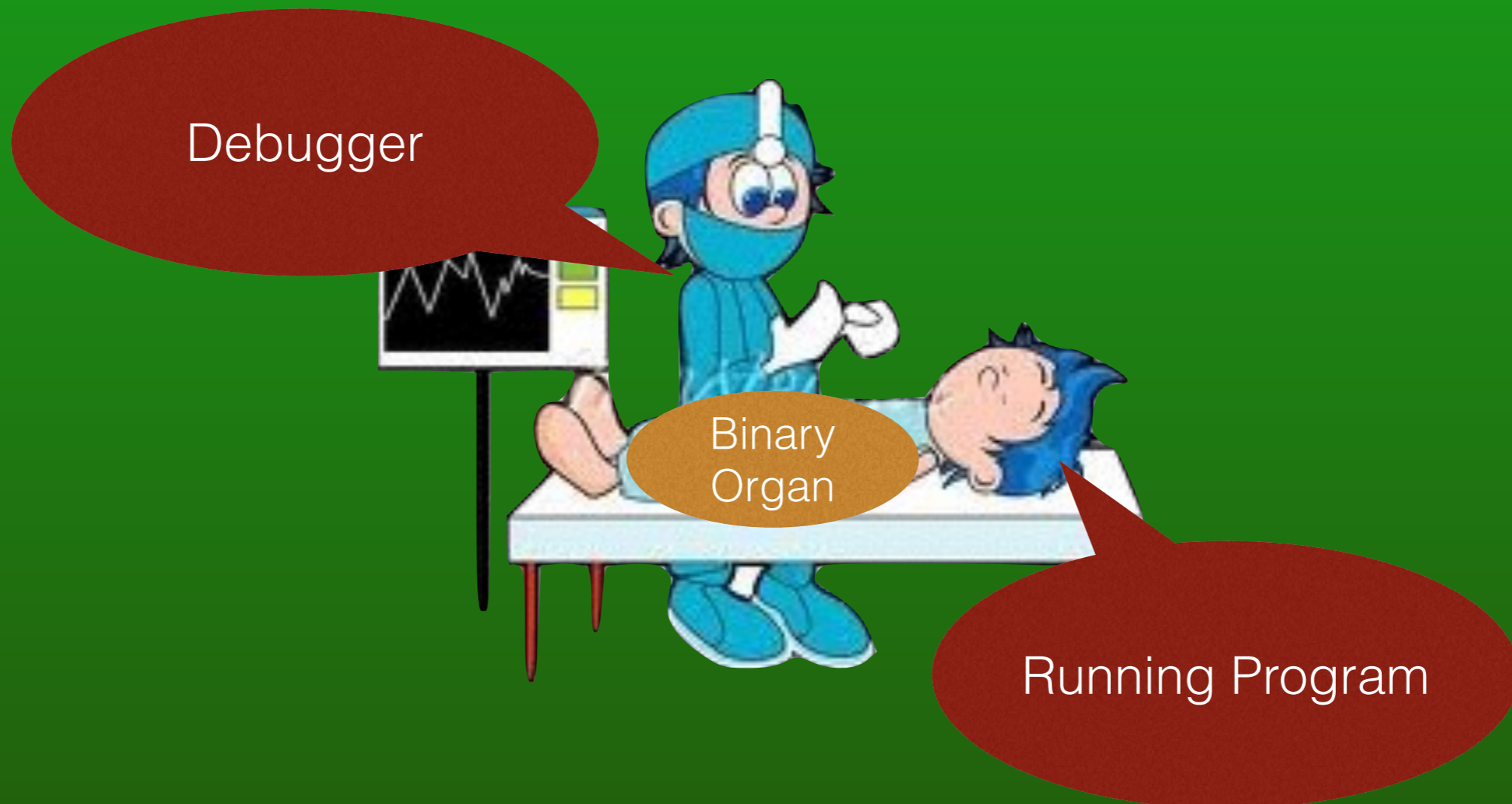
Related Work



Related Work

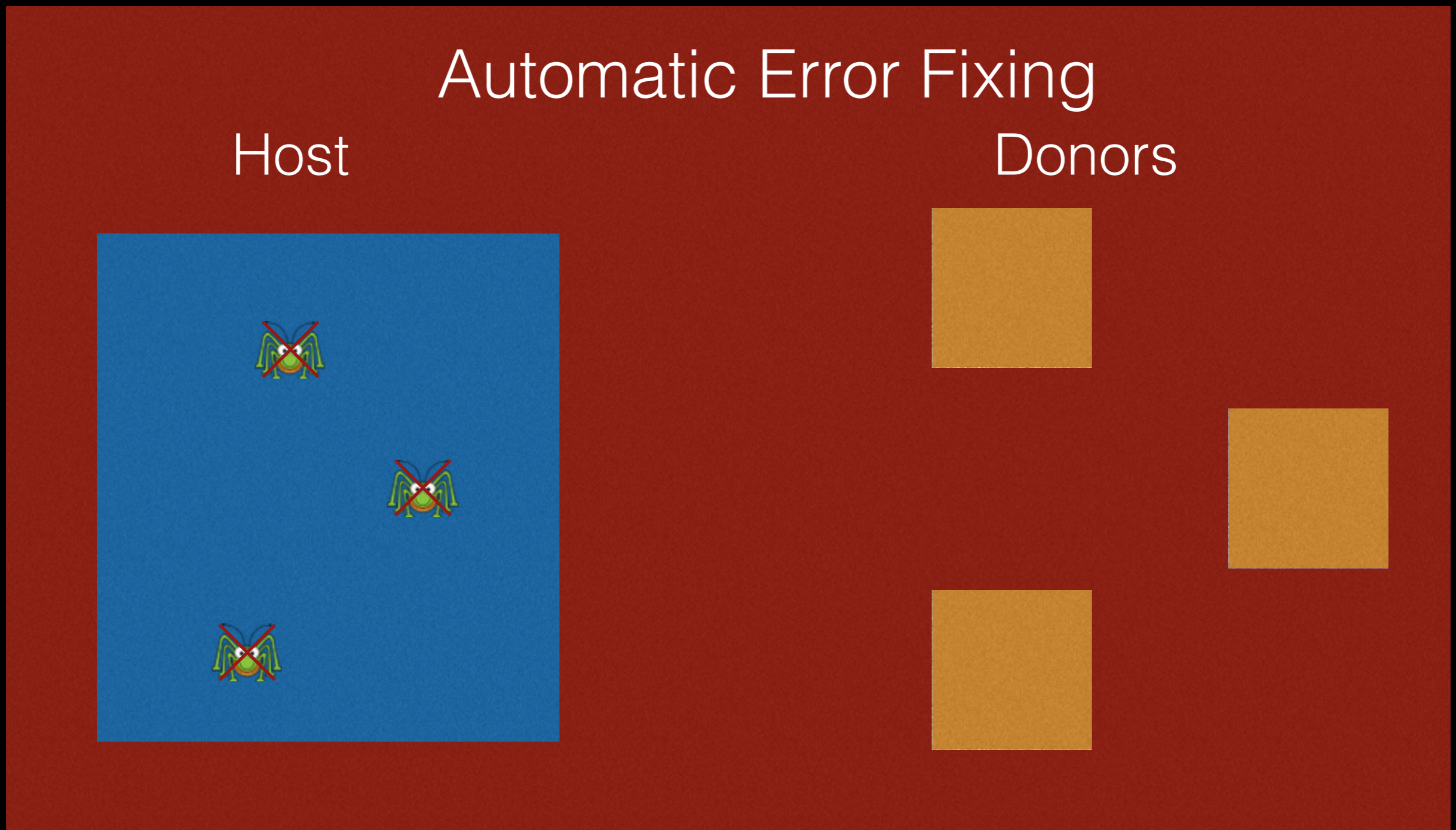
Miles *et al.*: In situ reuse of logically extracted functional components

In-Situ Code Reusal



Related Work

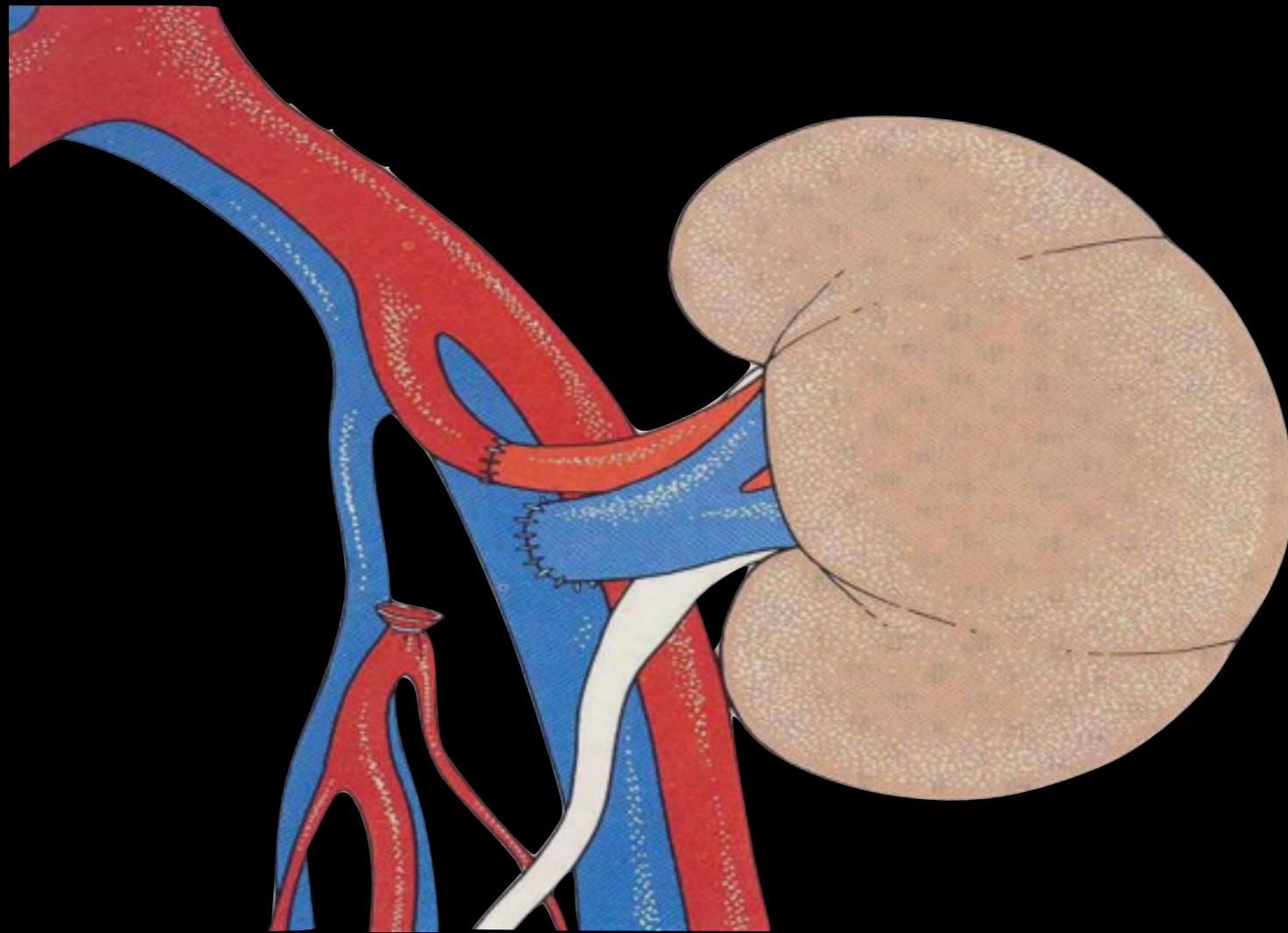
Sidiroglou-Douskos *et al.*: Automatic Error Elimination by Multi-Application Code Transfer



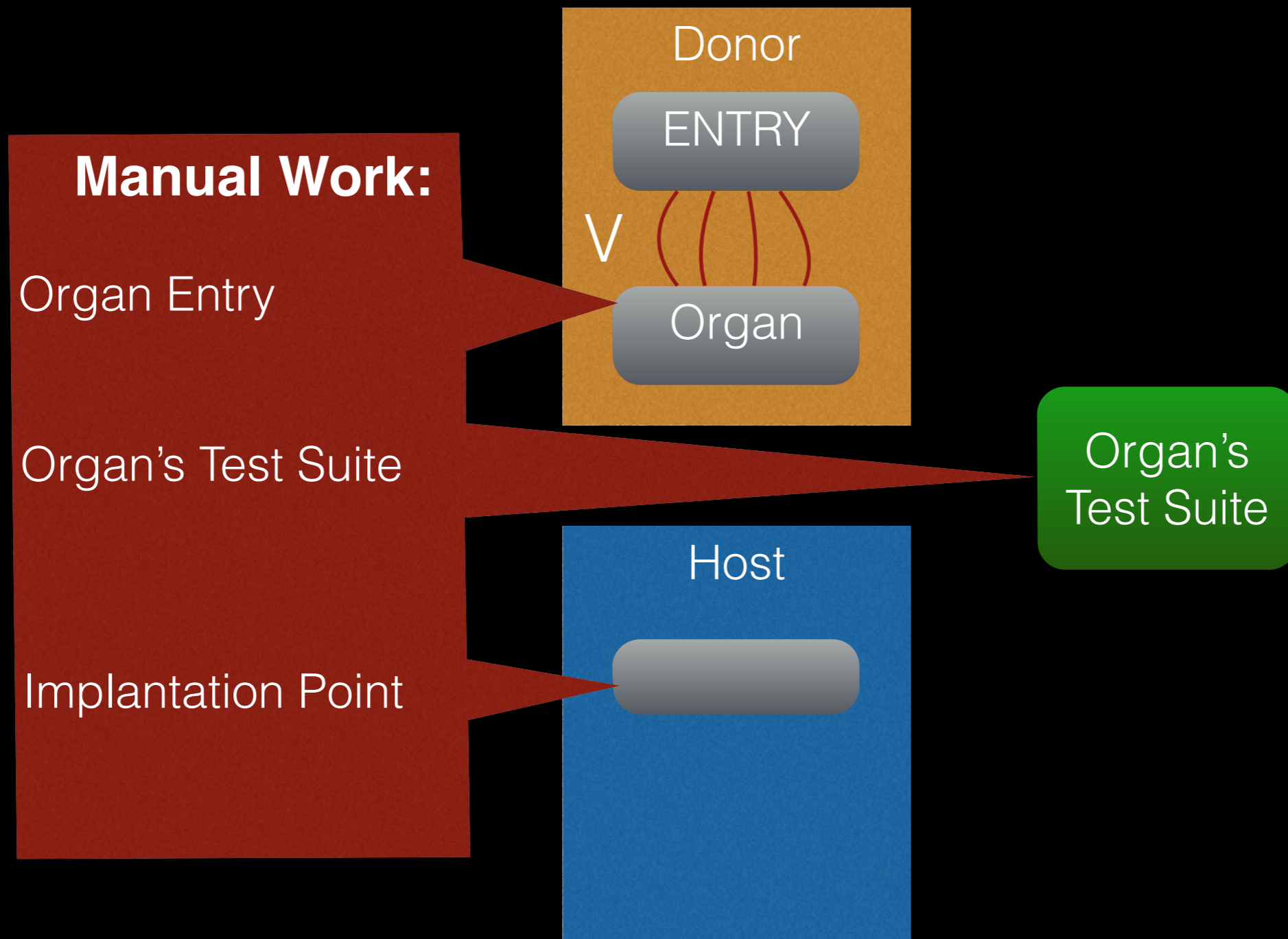
Related Work

Autotransplantation

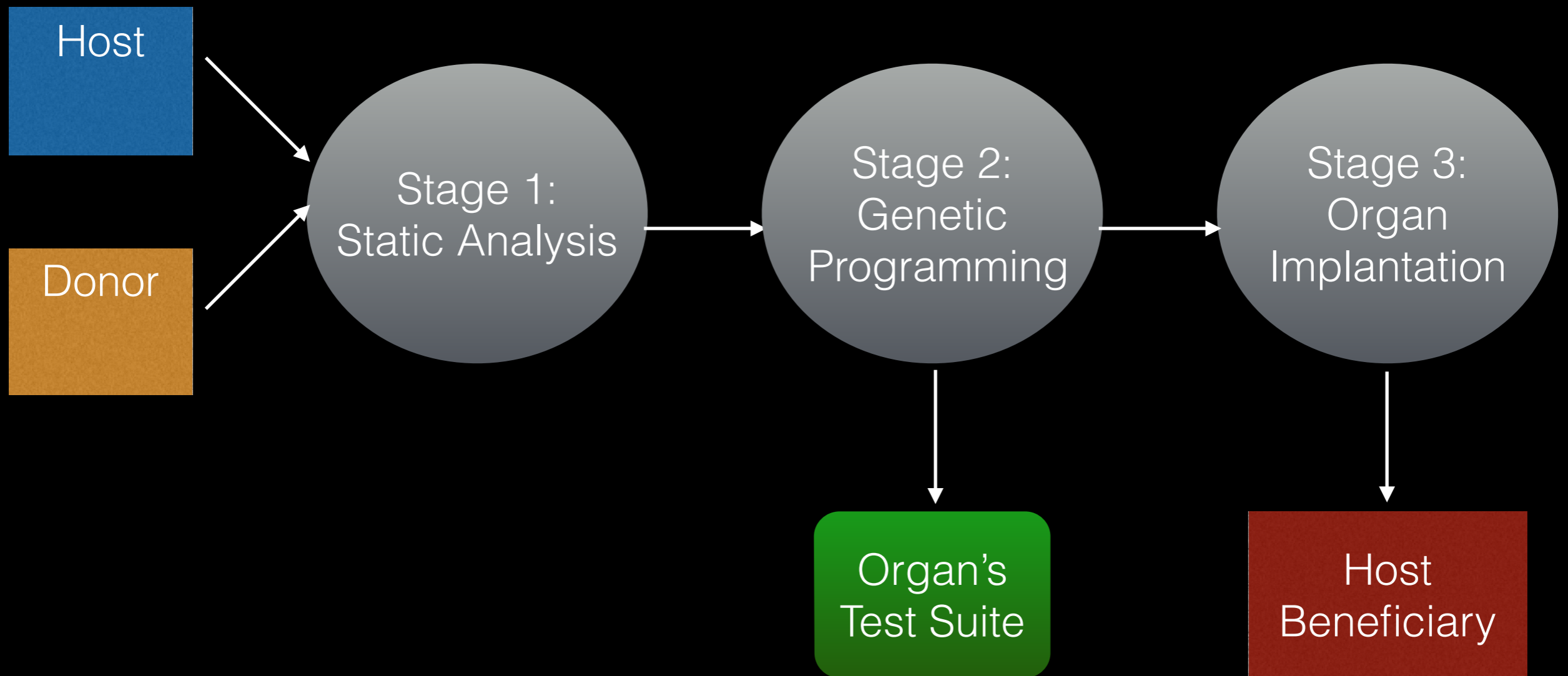
Human Organ Transplantation



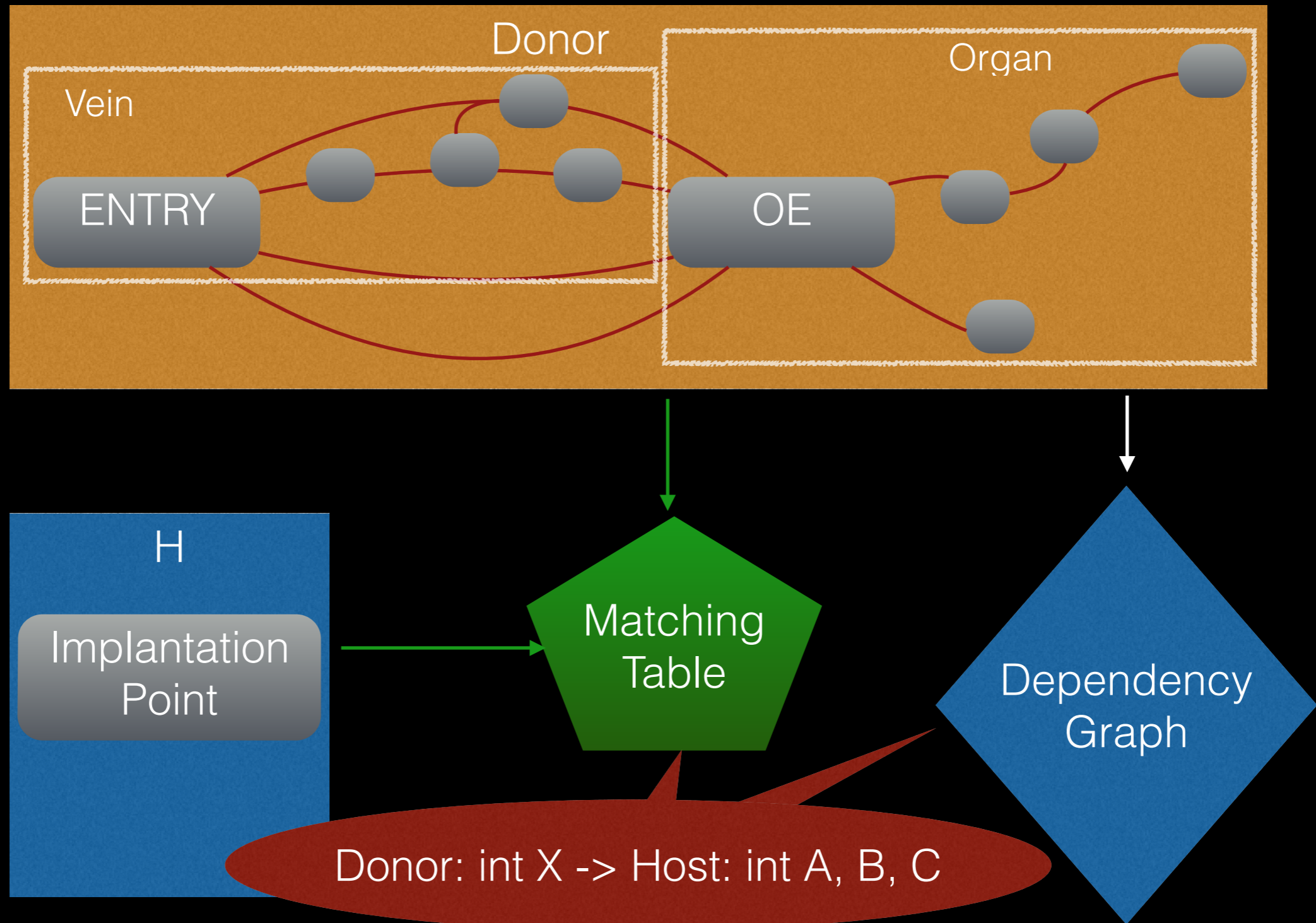
Automated Software Transplantation



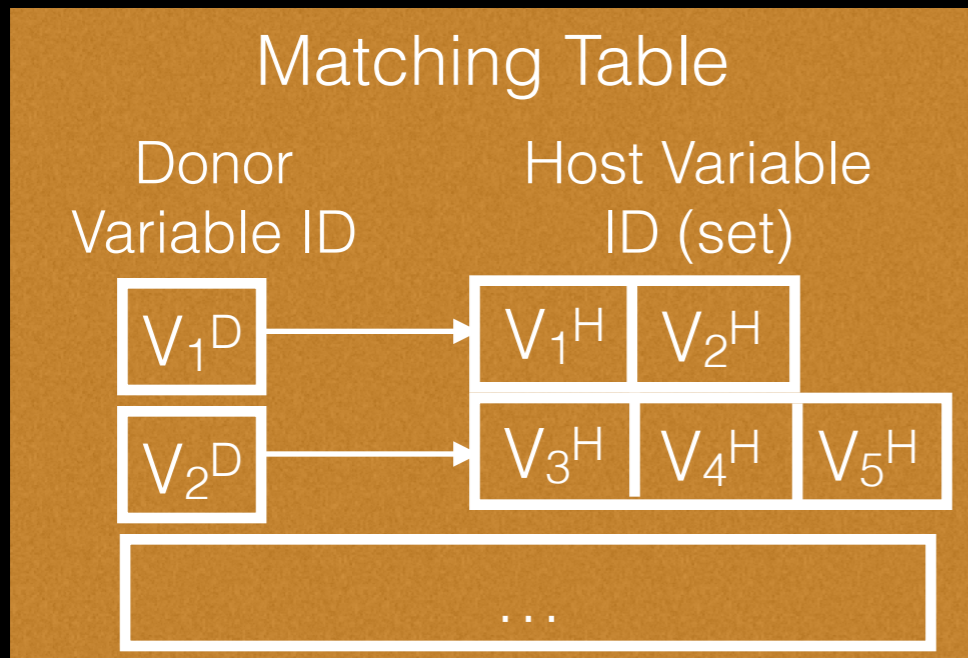
μTrans



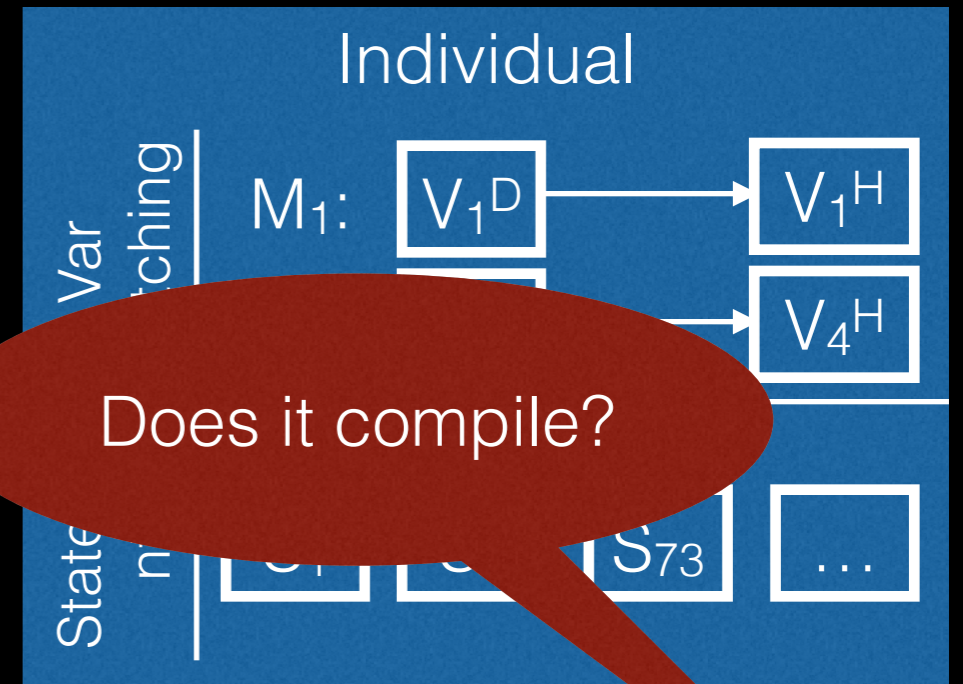
Stage 1 — Static Analysis



Stage 2 — GP



Genetic Programming



Does it compile?

$$fitness(i) = \begin{cases} \frac{1}{3} \left(1 + \frac{|TX_i|}{|T|} + \frac{|TP_i|}{|T|} \right) & i \in I_C \\ 0 & i \notin I_C \end{cases}$$

Weak Proxies:
Does it execute test cases without crashing?

Research Questions

Acceptance Tests

Host

Donor

RQ4: Is autotransplantation useful?

Research Questions

RQ1: Do we break the initial functionality?

RQ2: Have we really added new functionality?

Empirical Study

15 Transplantations
300 Runs
5 Donors
3 Hosts

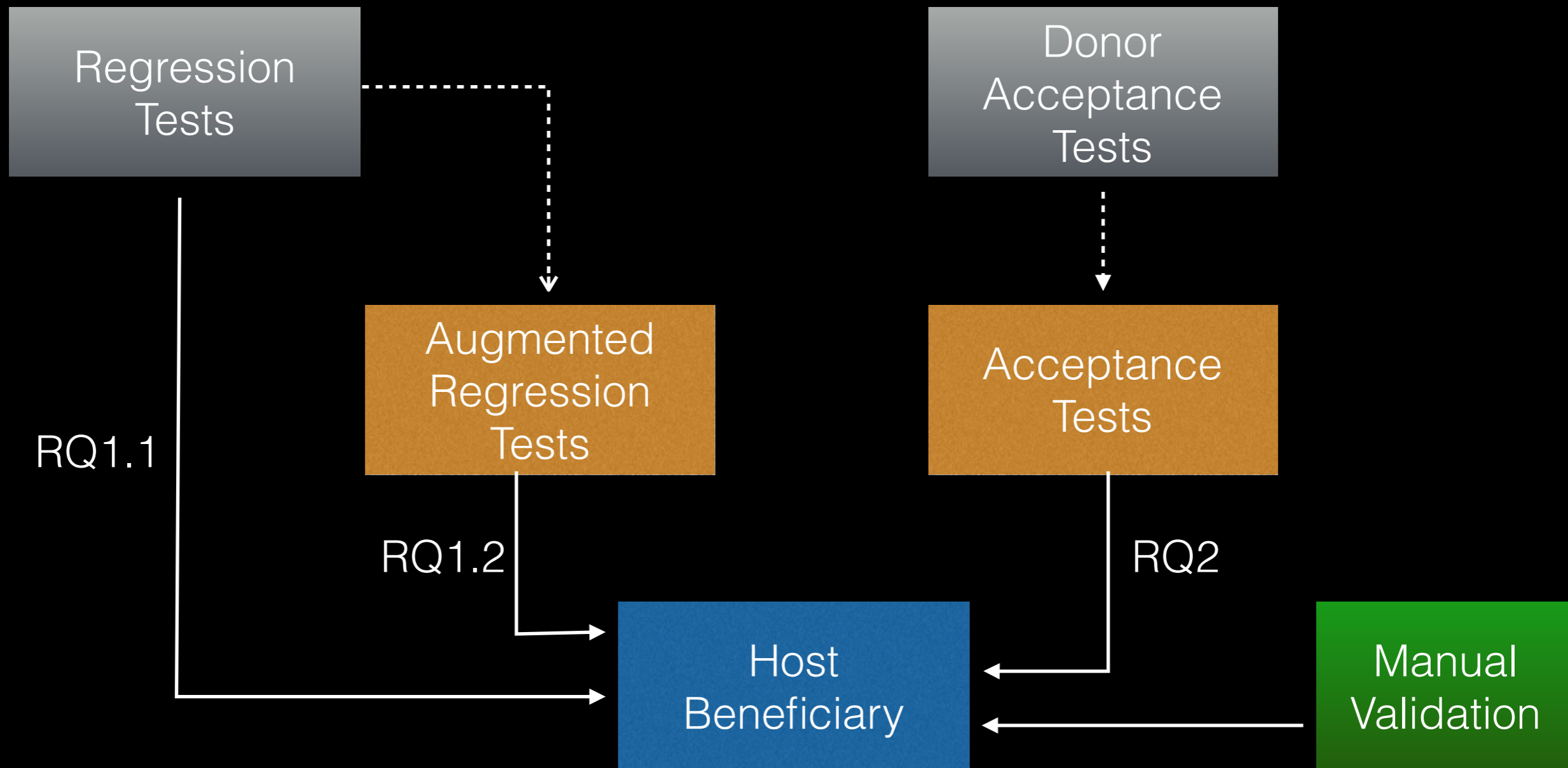
Case Study:

H.264 Encoding
Transplantation

RQ3: How about the computational effort?

RQ4: Is autotransplantation useful?

Validation





Subjects

Subjects	Type	Size KLOC	Reg. Tests	Organ Test Suite
Idct	Donor	2.3	-	3-5
Mytar	Donor	0.4	-	4
Cflow	Donor	25	-	6-20
Webserver	Donor	1.7	-	3
TuxCrypt	Donor	2.7	-	4-5
Pidgin	Host	363	88	-
Cflow	Host	25	21	-
SoX	Host	43	157	-
Case Study				
x264	Donor	63	-	5
VLC	Host	422	27	-

- Minimal size: 0.4k;
- Max size: 422k;
- Average Donor: 16k;
- Average Host: 213k;

Experimental Methodology

and

Count LOC
CLOC

Host

Implantation
Point

Donor

OE

Organ's
Test Suite

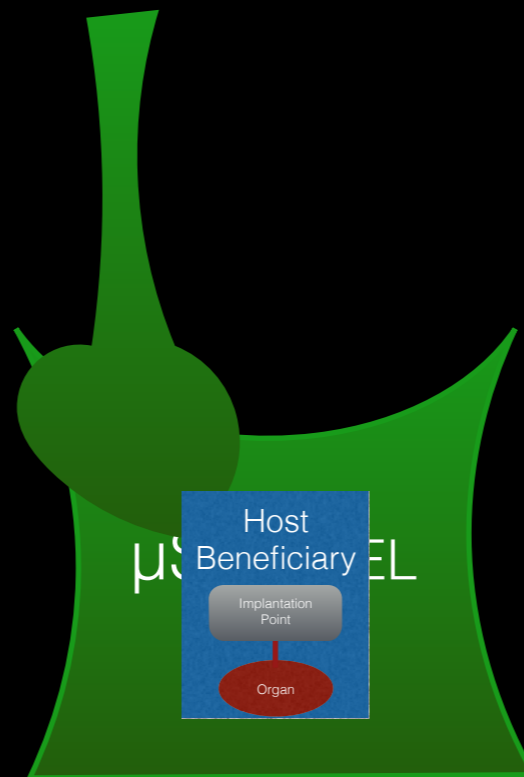
Validation Test
Suites

Coverage Information:
Gcov

x 20

GNU Time

Ubuntu 14.10, 16 GB Ram
8 threads





Empirical Study

RQ1,2

Donor	Host	All		Test Suites	
		Passed	Regression	Regression++	Acceptance
Idct	Pidgin	16	20	17	16
Mytar	Pidgin	16	20	18	20
Web	Pidgin	0	20	0	18
Cflow	Pidgin	15	20	15	16
Tux	Pidgin	15	20	17	16
Idct	Cflow	16	17	16	16
Mytar	Cflow	17	17	17	20
Web	Cflow	0	0	0	17
Cflow	Cflow	20	20	20	20
Tux	Cflow	14	15	14	16
Idct	SoX	15	18	17	16
Mytar	SoX	17	17	17	20
Web	SoX	0	0	0	17
Cflow	SoX	14	16	15	14
Tux	SoX	13	13	13	14
TOTAL		188/300	233/300	196/300	256/300
			RQ1.1	RQ1.2	RQ2



Empirical Study

RQ3

Timing Information

		Execution Time (minutes)		
Donor	Host	Average	Std. Dev.	Total
Idct	Pidgin	5	7	97
Mytar	Pidgin	3	1	65
Web	Pidgin	8	5	160
Cflow	Pidgin	58	16	1151
Tux	Pidgin	29	10	574
Idct	Cflow	3	5	59
Mytar	Cflow	3	1	53
Web	Cflow	5	2	102
Cflow	Cflow	44	9	872
Tux	Cflow	31	11	623
Idct	SoX	12	17	233
Mytar	SoX	3	1	60
Web	SoX	7	3	132
Cflow	SoX	89	53	74
Tux	SoX	34	13	94
Total		334 (min)	10 (Average)	72 (hours)
RQ3				



Case Study

RQ4

Second Annual MSU MPEG-4 AVC/ H.264 Codecs Comparison

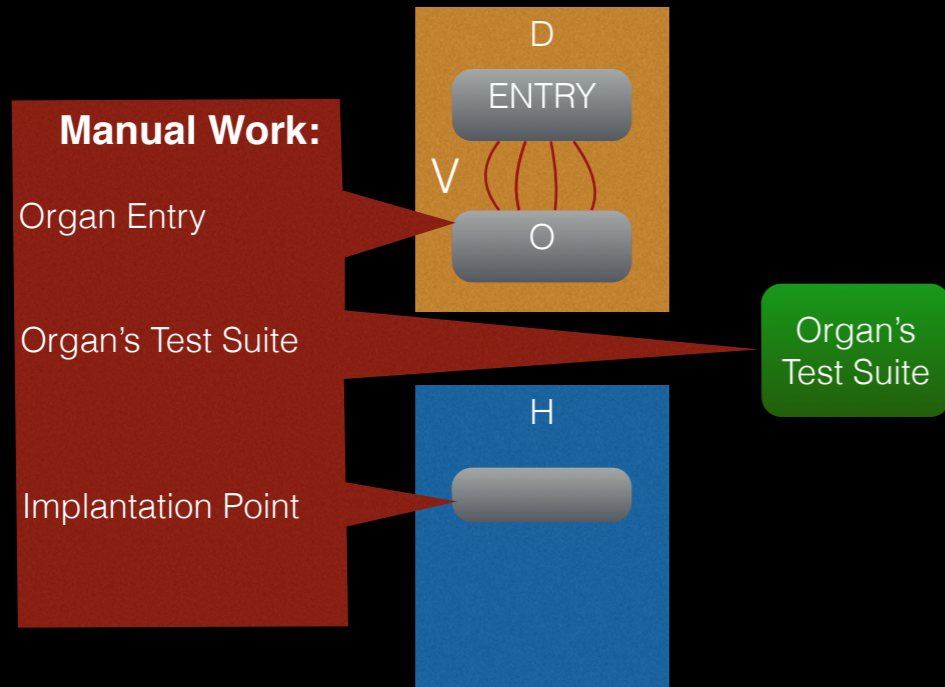
MSU Sixth MPEG-4 AVC/H.264 Video Codecs Comparison, with ~24% better encoding than second place.

		Regression+ Acceptance	
H.264		100%	100%

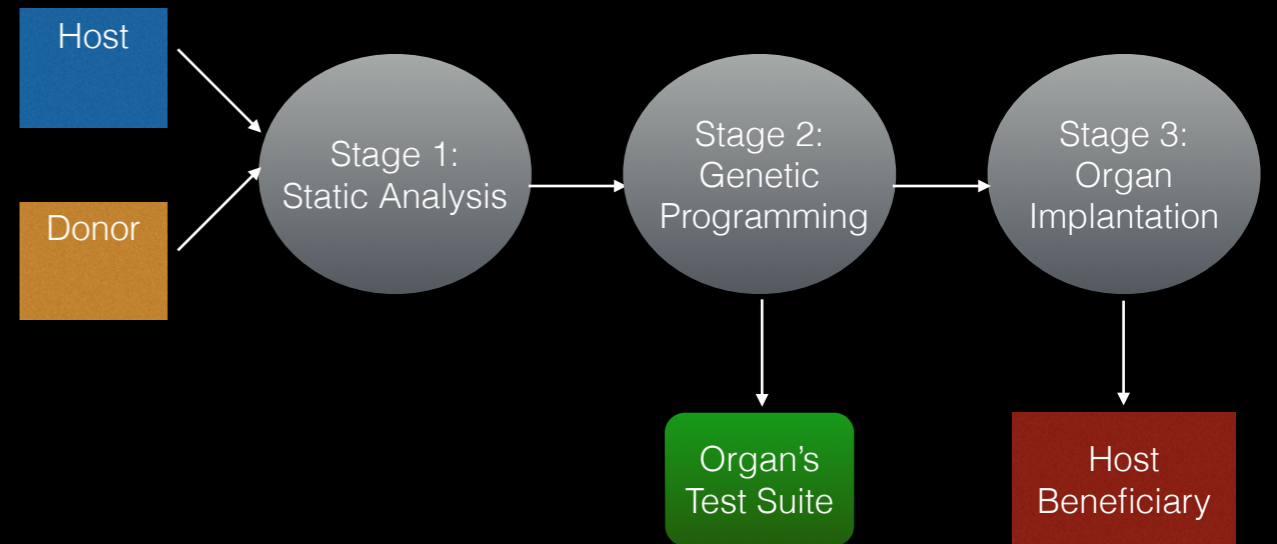
Doom9's 2005 Codec Shoot-Out



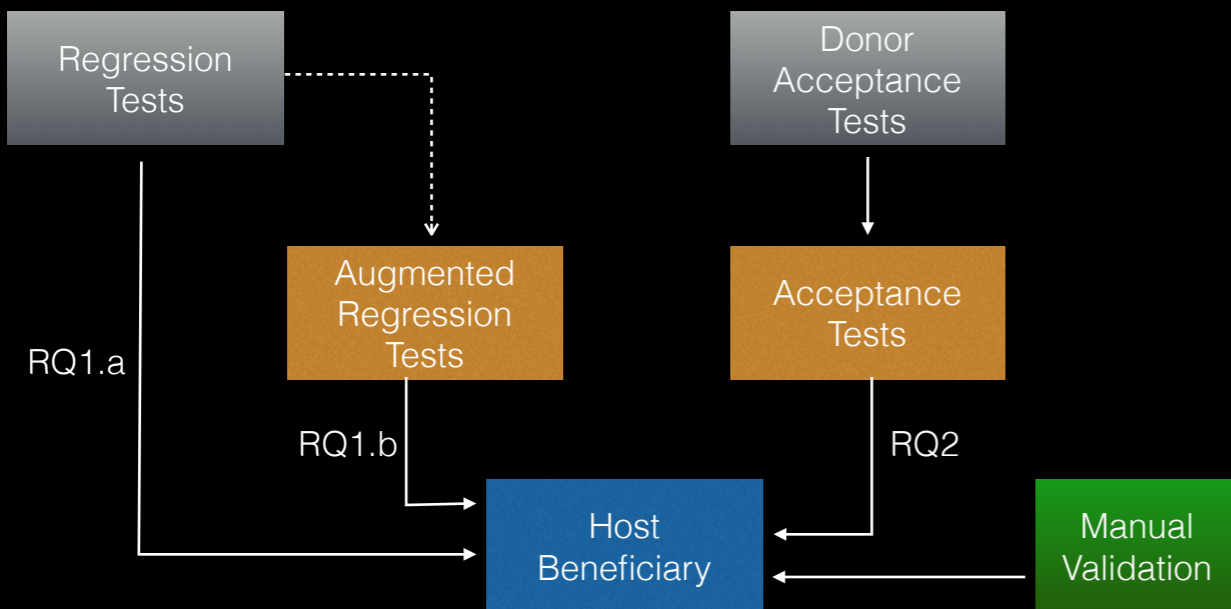
Automated Software Transplantation



μTrans



Validation



Subjects

Subjects	Type	Size KLOC	Reg. Tests	Organ Test Suite
Idct	Donor	2.3	-	3-5
Mytar	Donor	0.4	-	4
Cflow	Donor	25	-	6-20
Webserver	Donor	1.7	-	3
TuxCrypt	Donor	2.7	-	4-5
Pidgin	Host	363	88	-
Cflow	Host	25	21	-
SoX	Host	43	157	-
Case Study				
x264	Donor	63	-	5
VLC	Host	422	27	-

- Minimal size: 0.4k;
- Max size: 422k;
- Average Donor: 16k;
- Average Host: 213k;