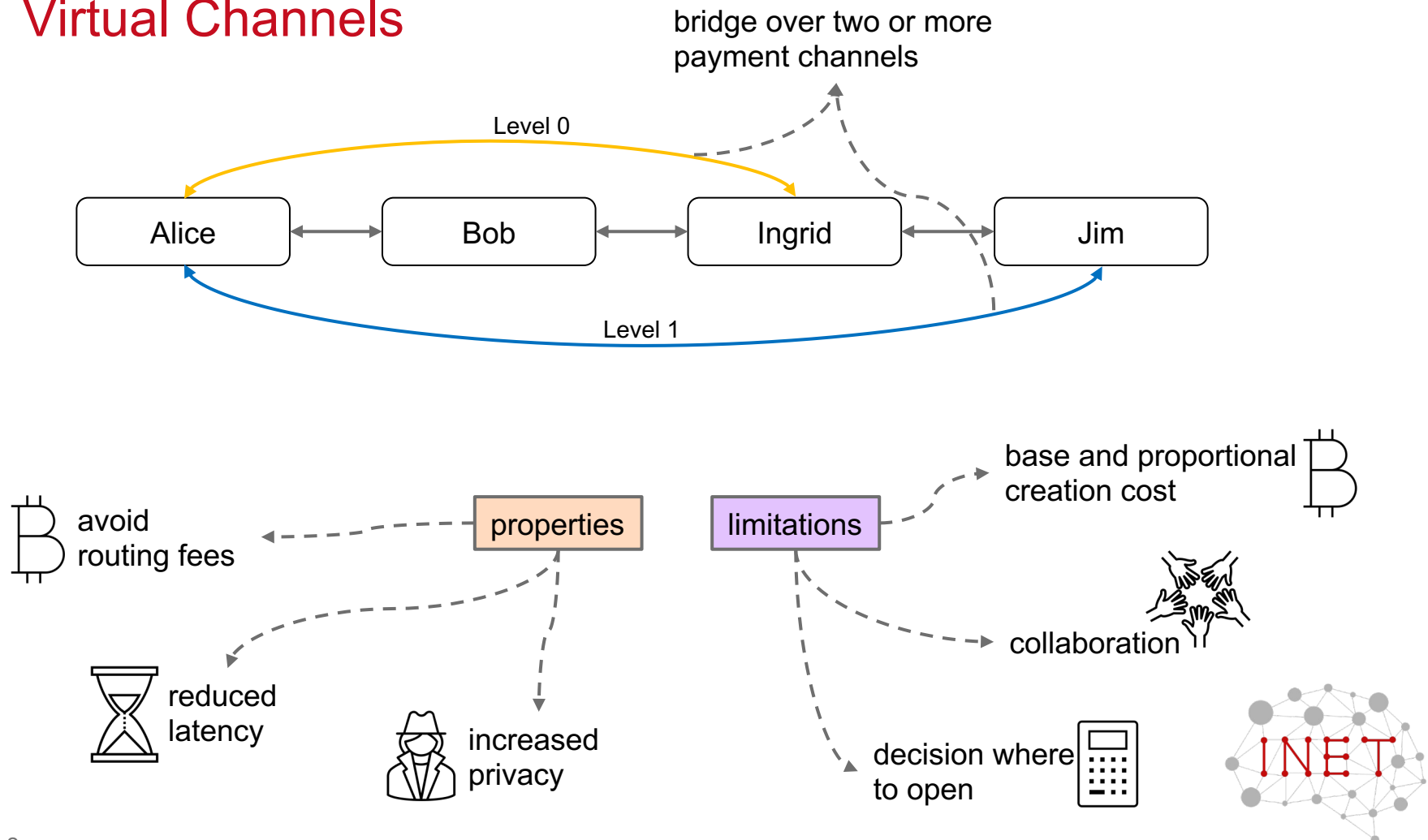


Optimizing Virtual Channels in Payment Channel Networks

Network Architecture Project

Yannik Kopyciok, supervisor: Iosif Salem

Virtual Channels



VC optimization - ILP

Objective: Minimization of fees

C1: Transaction path uniqueness

C2: Transaction success rate

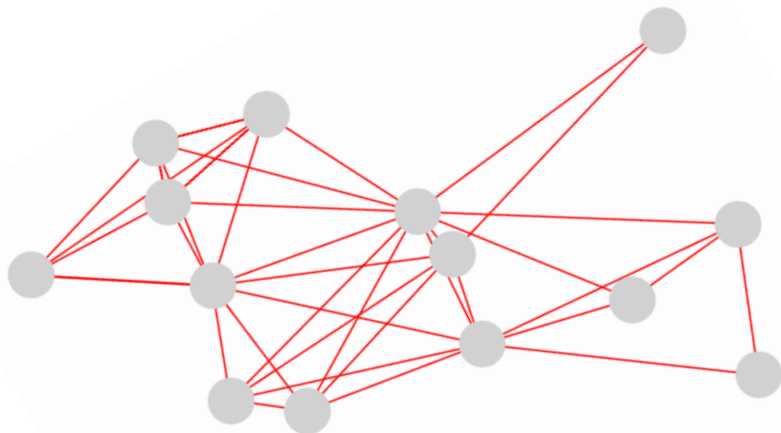
C3: Capacity restriction

C4: VC existence

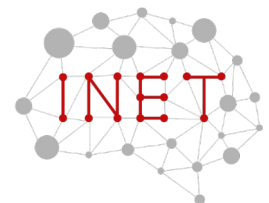
C5: Known adversaries

ILP in matrix form:

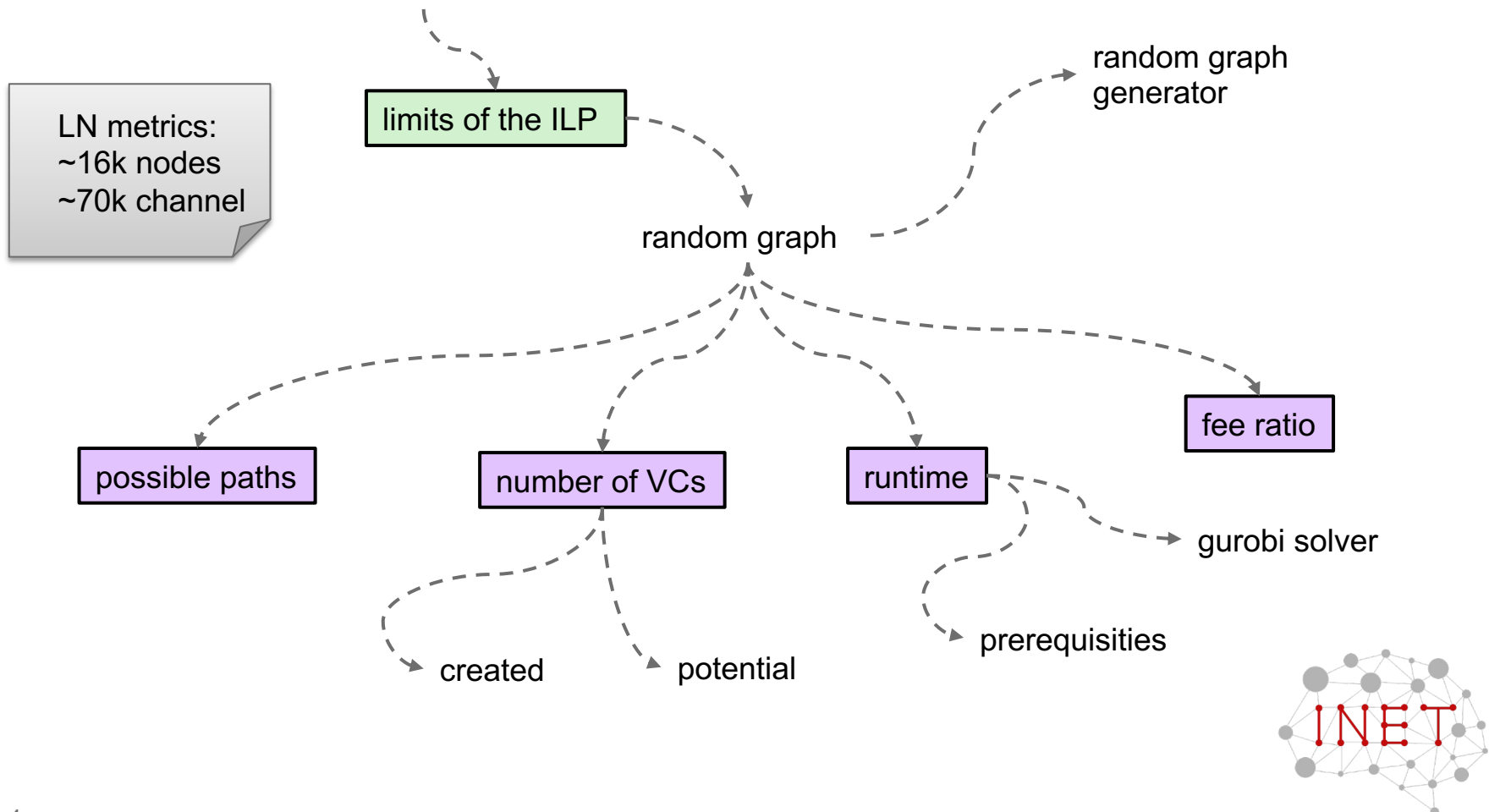
$$\begin{aligned} \min & \mathbf{c}^T \cdot \mathbf{x} \\ \text{such that} \\ & \mathbf{A} \cdot \mathbf{x} \geq \mathbf{b} \\ & \mathbf{x} \geq 0 \end{aligned}$$



 **GUROBI**
OPTIMIZATION
<https://www.gurobi.com>



Evaluation - objective



Evaluation - graph example

fully connected:

$$\frac{n * (n - 1)}{2}$$

graph with
9 nodes

increasing
edges

lower bound: 9

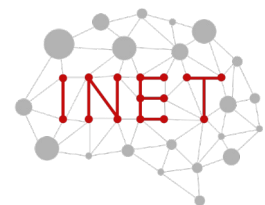
upper bound: 36

10 random graphs
to get an average

```

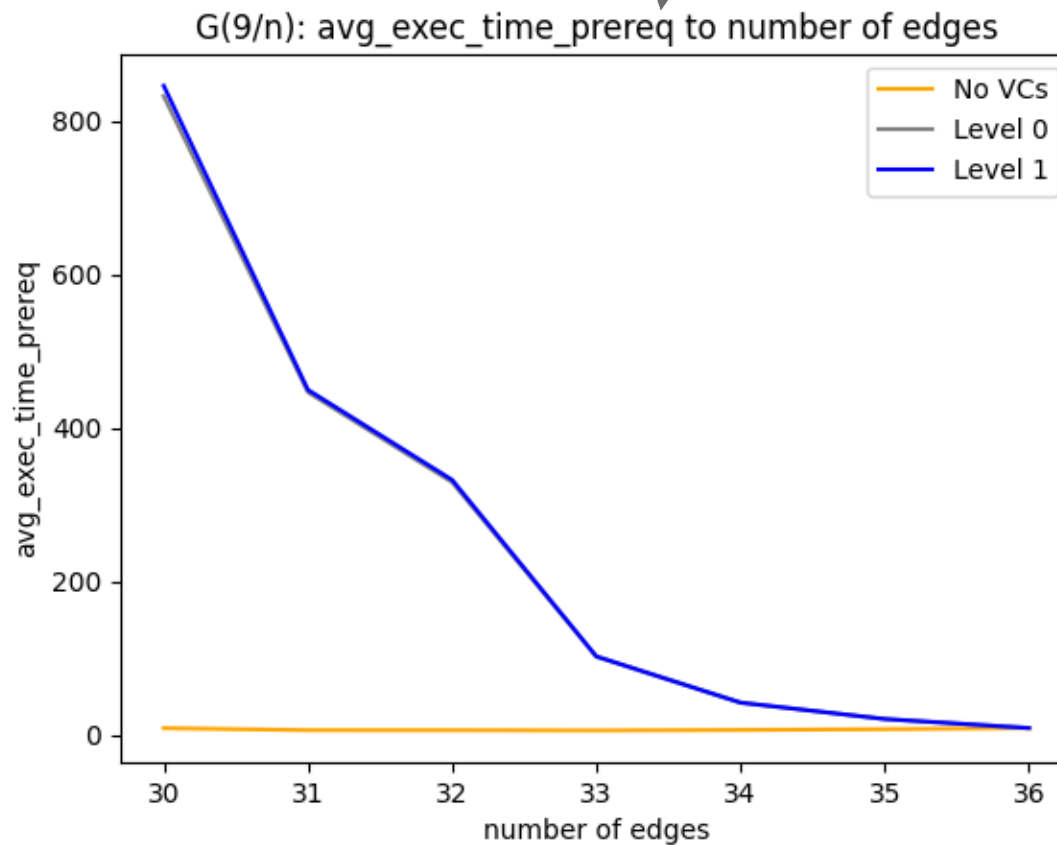
1  nodes PCs graph_id level exec_time_prereq exec_time_gurobi VCs pot_paths objective
2  9 30 0 -1 4.585318474 0.06238144599999984 0 13366 31.0
3  9 30 0 0 471.489058288 21.860478774 30 745590 21.0
4  9 30 0 1 460.226014314 21.355742385999974 30 745590 21.0
5  9 30 1 -1 6.117597516000046 0.11861320299999534 0 10778 15.0
6  9 30 1 0 907.433407287 94.86654424500011 32 1291664 15.0
7  9 30 1 1 897.4917598009997 95.19962877299986 32 1291664 15.0
8  9 30 2 -1 9.898214192999603 0.12677771700009544 0 8528 0.0
9  9 30 2 0 1082.2911738510002 82.97925149399998 30 1447842 0.0
10 9 30 2 1 1076.9432199539997 70.89855554099995 30 1447842 0.0
11 9 30 3 -1 13.867645166999864 0.17952812000021368 0 11643 16.0
12 9 30 3 0 306.07104101799996 12.685693420000462 28 550052 16.0
13 9 30 3 1 308.9841223119993 12.950374643000032 28 550052 16.0
14 9 30 4 -1 6.126527344000351 0.09863007200056018 0 11267 19.0
15 9 30 4 0 1351.9437073869994 204.4890688559999 35 1623290 10.0
16 9 30 4 1 1376.6203599550008 169.18242989600003 35 1623290 10.0
17 9 30 5 -1 15.181261602001541 0.1585567260008247 0 8905 20.0
18 9 30 5 0 600.5034551130011 29.12925787899985 28 974586 10.0
19 9 30 5 1 621.1277981470012 31.921485628001392 28 974586 10.0
20 9 30 6 -1 10.53828952600088 0.11739800299983472 0 12210 11.0
21 9 30 6 0 800.5062307879998 72.164274312001 32 1103928 11.0
22 9 30 6 1 769.6139643899987 102.16272022500016 32 1103928 11.0
23 9 30 7 -1 12.466396522999275 0.12027443499937363 0 10022 12.0
24 9 30 7 0 968.6730071500006 71.59837691299981 32 1372052 10.0

```



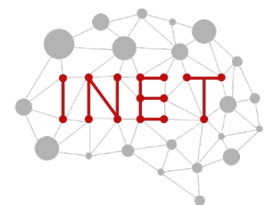
Evaluation - runtime

filling the sparse matrix

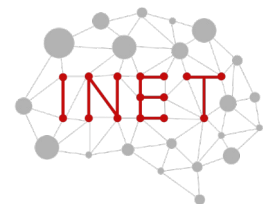
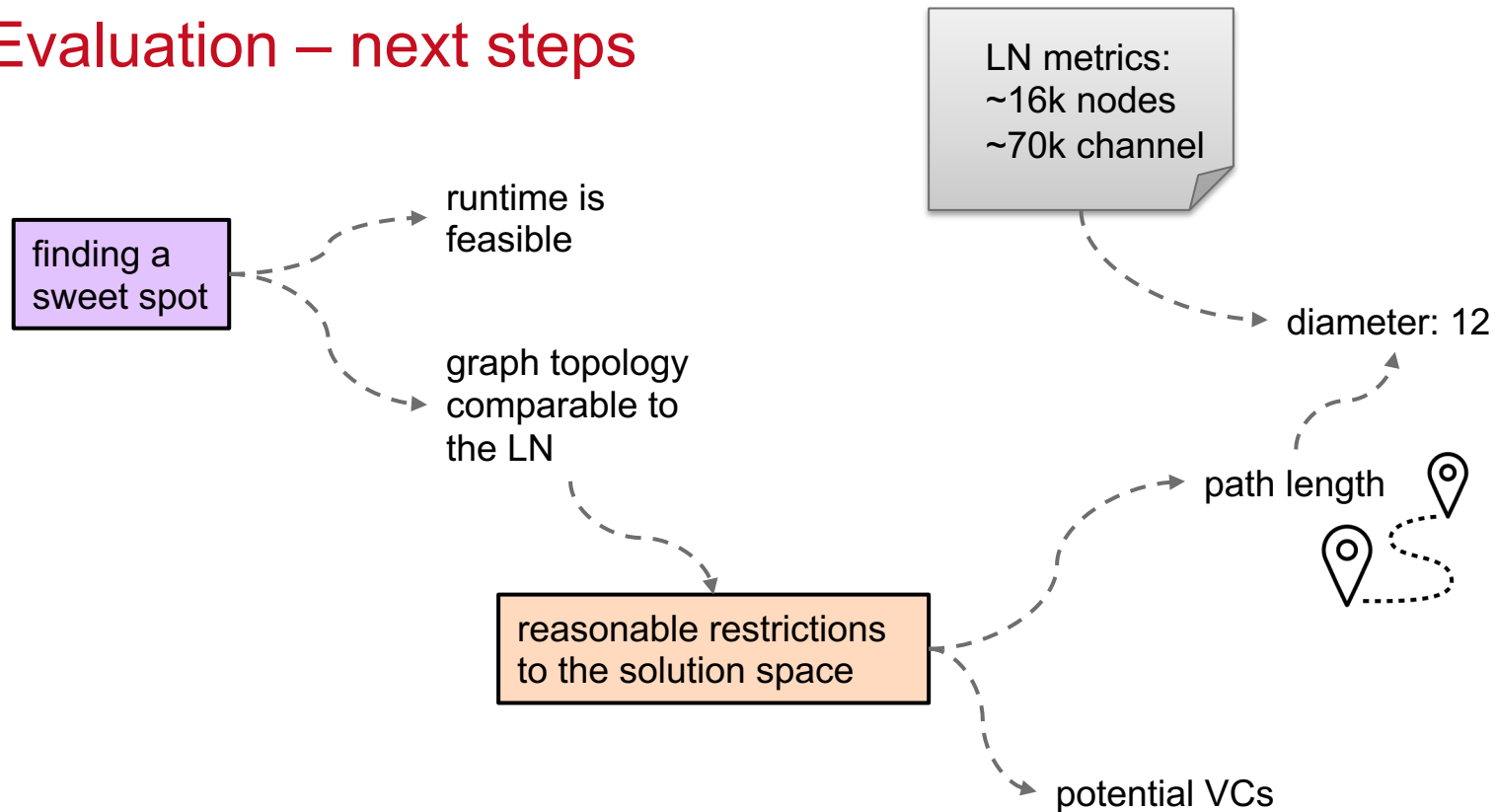


fully connected:

$$\frac{n * (n - 1)}{2}$$

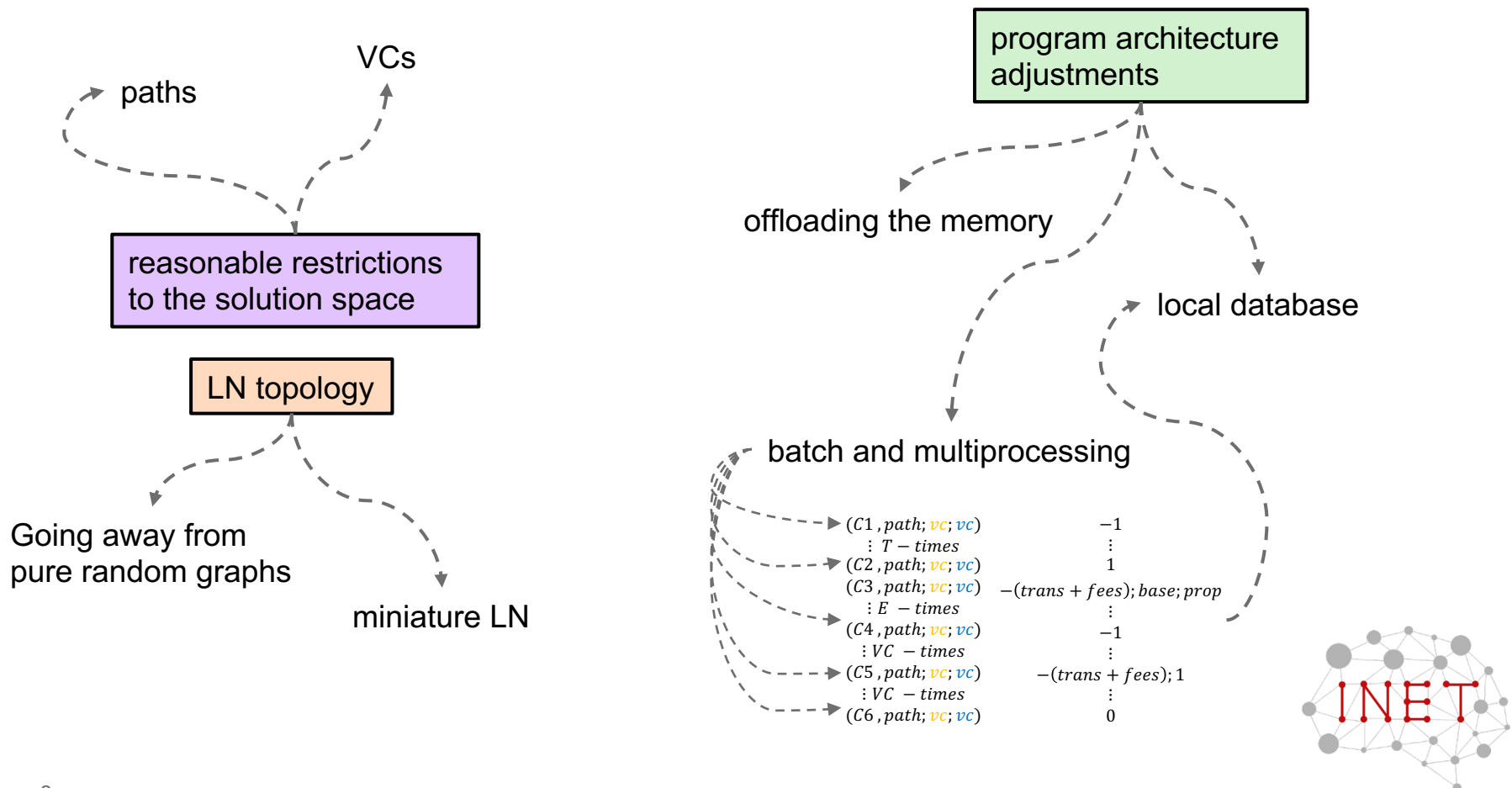


Evaluation – next steps





Future work





Questions?

Feedback?

Impulses?

