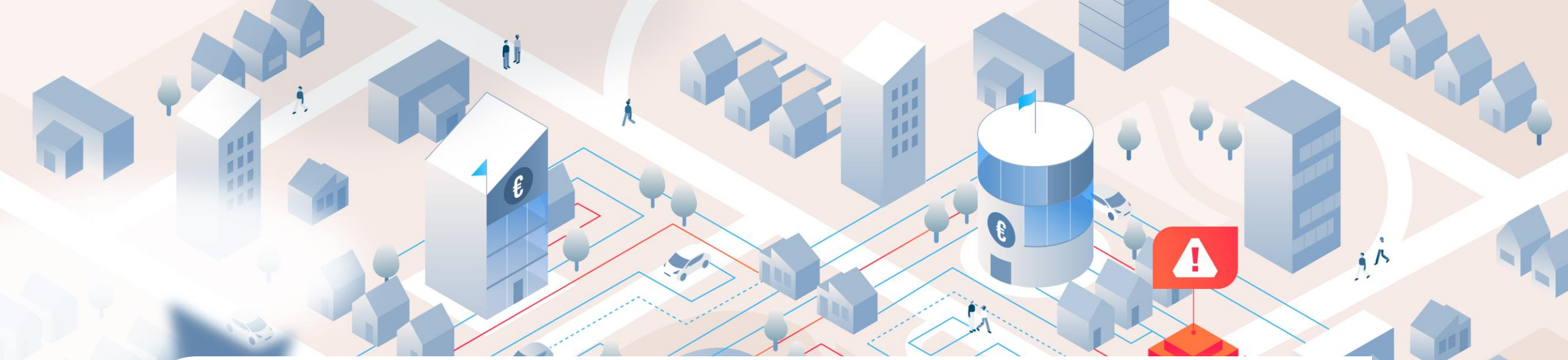

Topology-Agnostic Detection of Temporal Money Laundering Flows in Billion-Scale Transactions

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TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

TMNL Transactie Monitoring Nederland

MIDAS @ ECML PKDD 2023 | Turin, Italy 22 September 2023

A framework for detecting money laundering networks

- Background and problem formulation
- Challenges and key contributions
  - Scalable
  - Topology (and typology) agnostic
  - Minimum assumptions (filtering, grouping, etc.)
  - Applicable to a multi-bank setting
- Experimental evaluation on real data
- Conclusion

Money laundering is a threat to society

- An estimated **16 billion Euros annually** are laundered just in the Netherlands
- Laundering money is of key importance to the financing of **criminal activity**
- Therefore, causing **human suffering** and large damage to society

Money laundering is a threat to society

Criminals
obtain “dirty money”
from illicit activities

- Human trafficking
- Corruption
- Drug trafficking
- Terrorism

Money laundering is a threat to society

Criminals
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“Dirty money” is difficult
to use for investments

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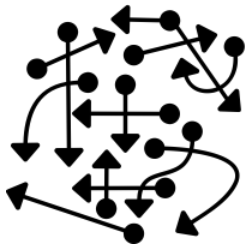
“Dirty money” is difficult
to use for investments

”Dirty money” is “laundered”
by making it flow in complex
patterns through the financial
system, obfuscating its origin



Money laundering is a threat to society

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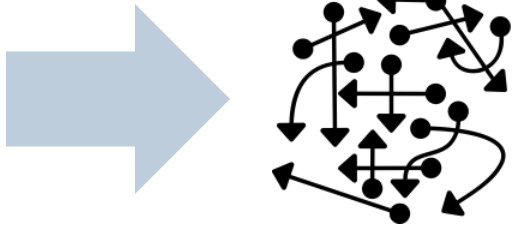


”Dirty money” is “laundered”
by making it flow in complex
patterns through the financial
system, obfuscating its origin

… turning it into “clean”
hence investable money

Transaction Monitoring Netherlands (TMNL)

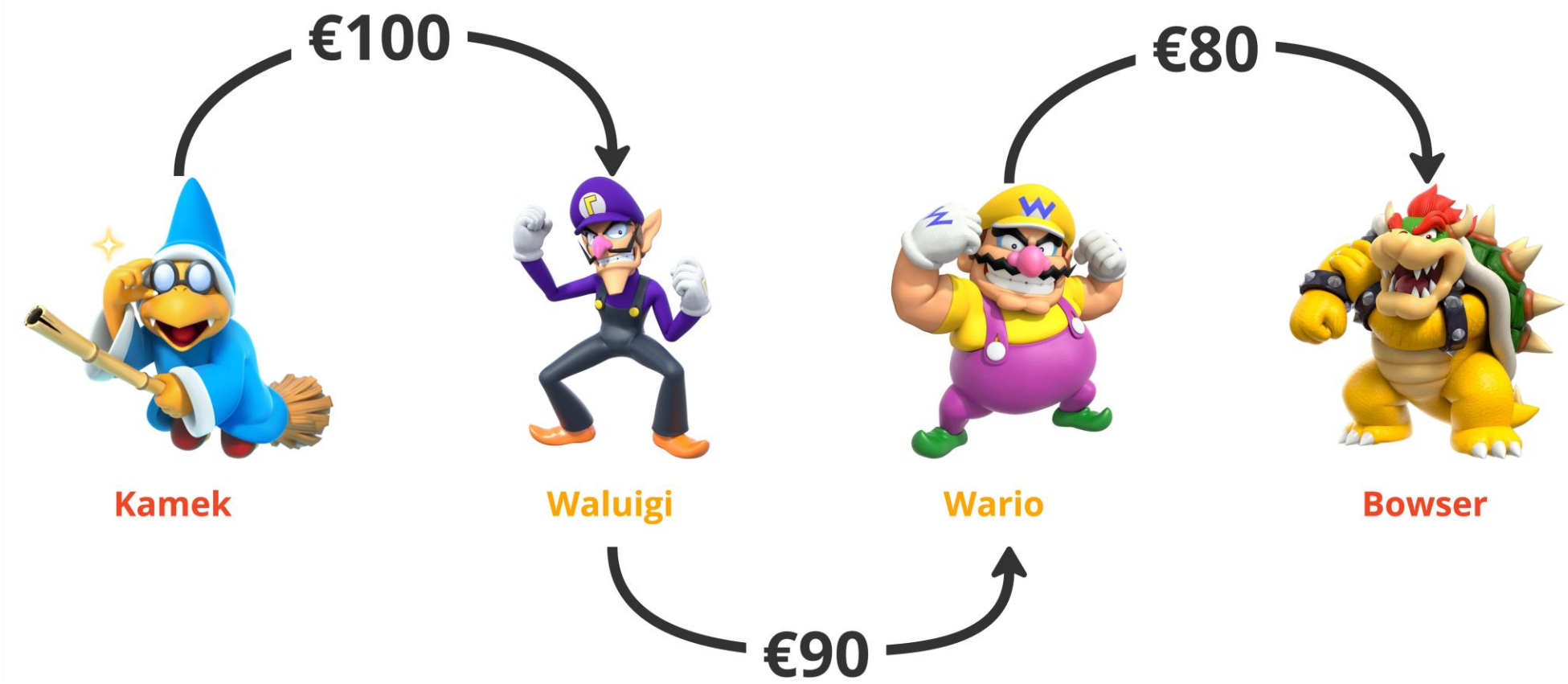
We're fighting money laundering at an unprecedented scale

- Joint venture of 5 Dutch banks: ING ABN·AMRO de volksbank Triodos Bank Rabobank
- **Pooling pseudonymized transaction** data (of businesses) at TMNL
- The larger the **transaction graph**, the better we can detect money laundering
  - … consequently, the more complex the problem becomes
- We build **models** that detect unusual patterns on the inter-bank transaction graph that might indicate money laundering

Anti Money Laundering (AML) Modeling

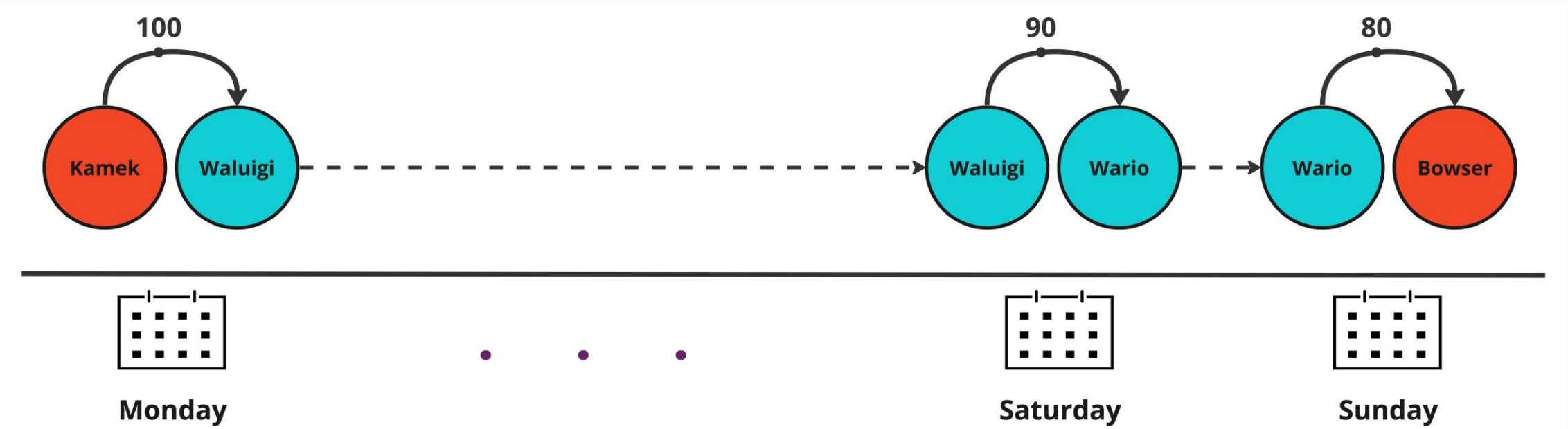
- Needle-in-a-haystack problem
- Complex and ever evolving money-laundering patterns
- Computationally expensive
- Lack of data features (due to privacy, bias, etc.)

What is a flow?

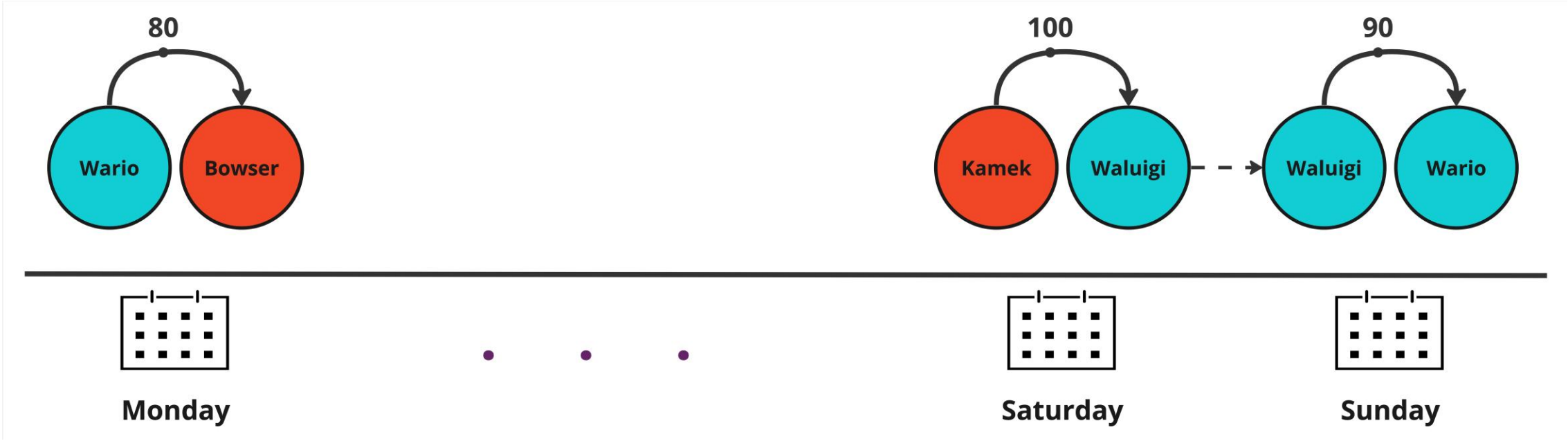


Criminal | **Agent**

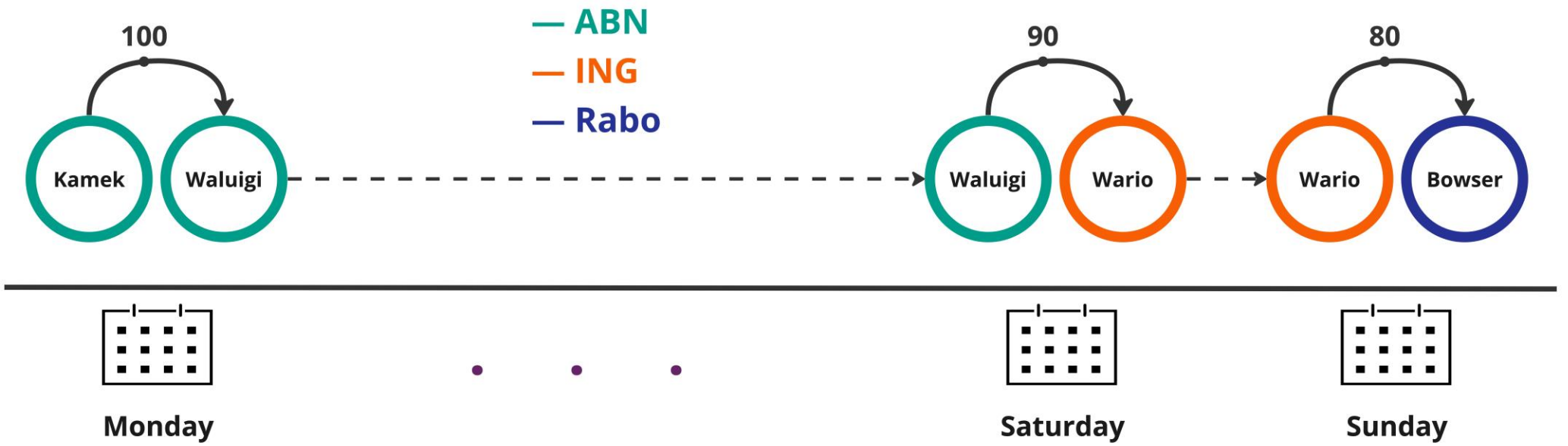
What is a flow?



Is this a flow?



Why complicate things?



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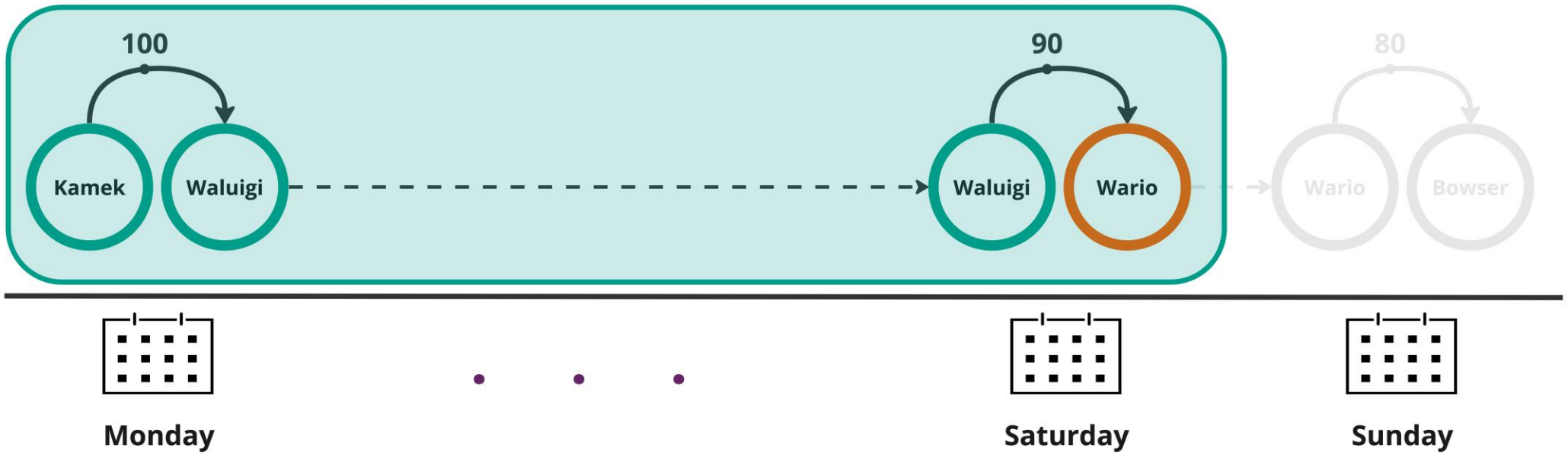

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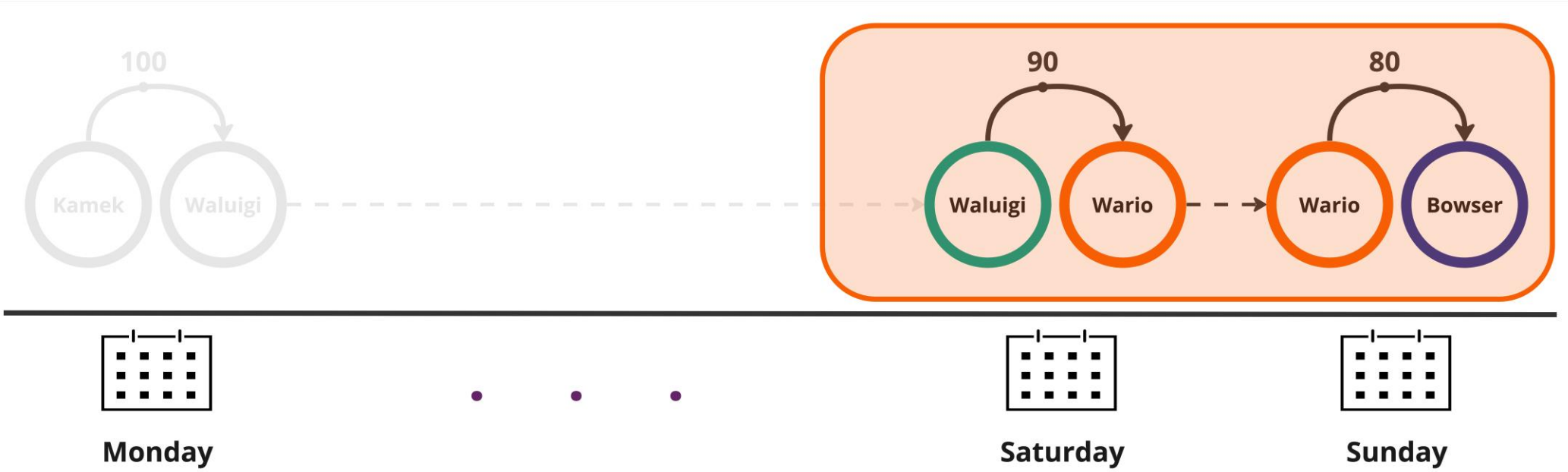

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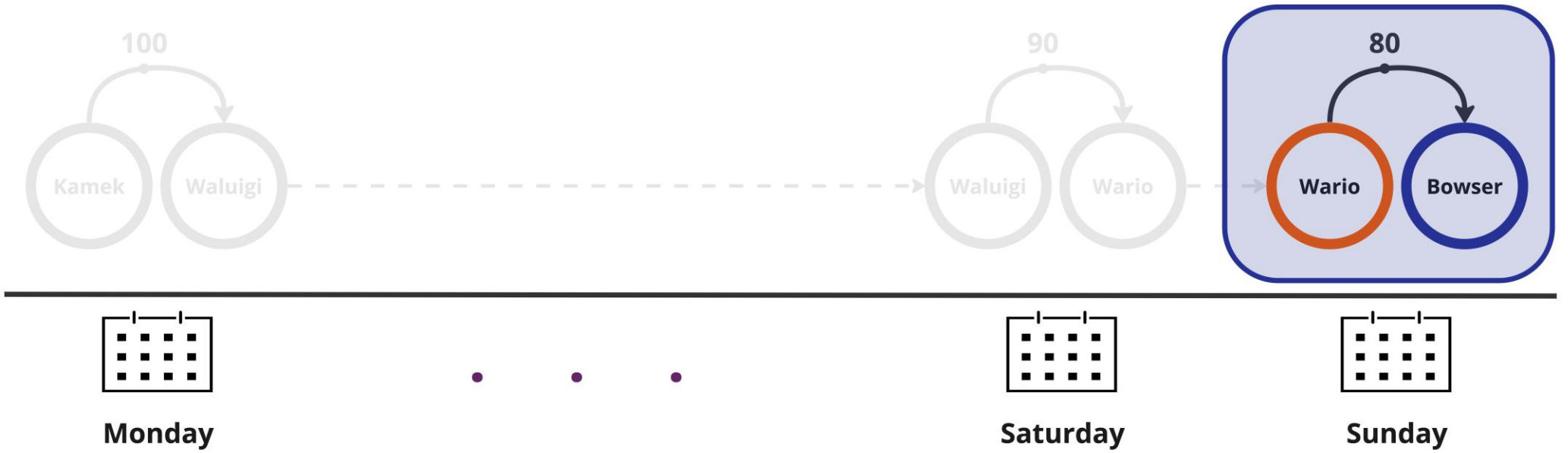

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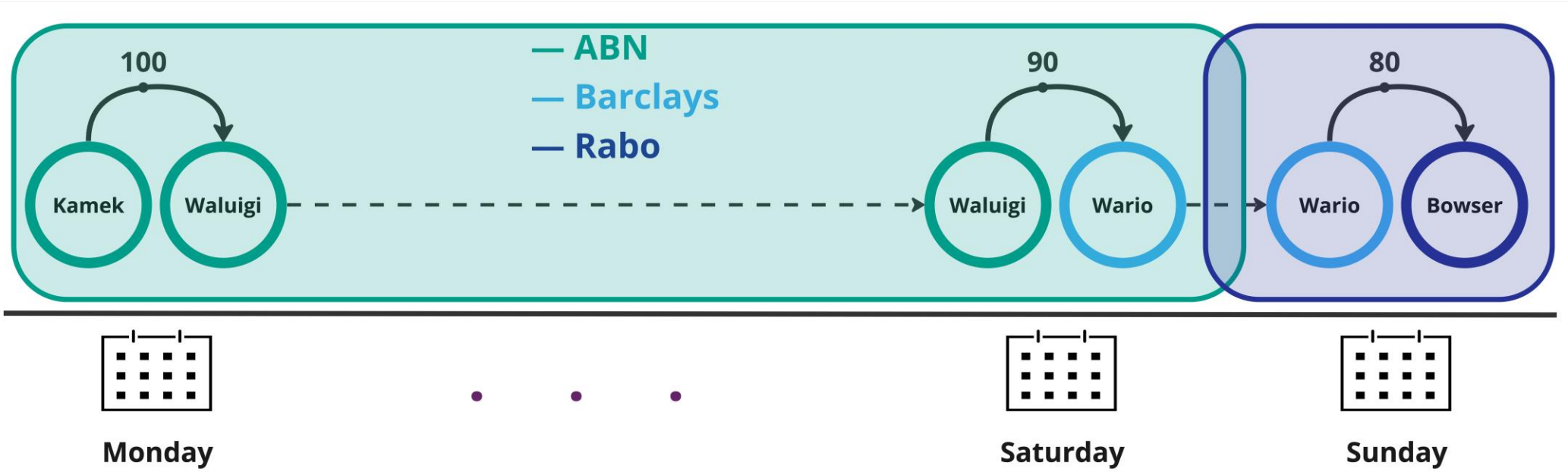
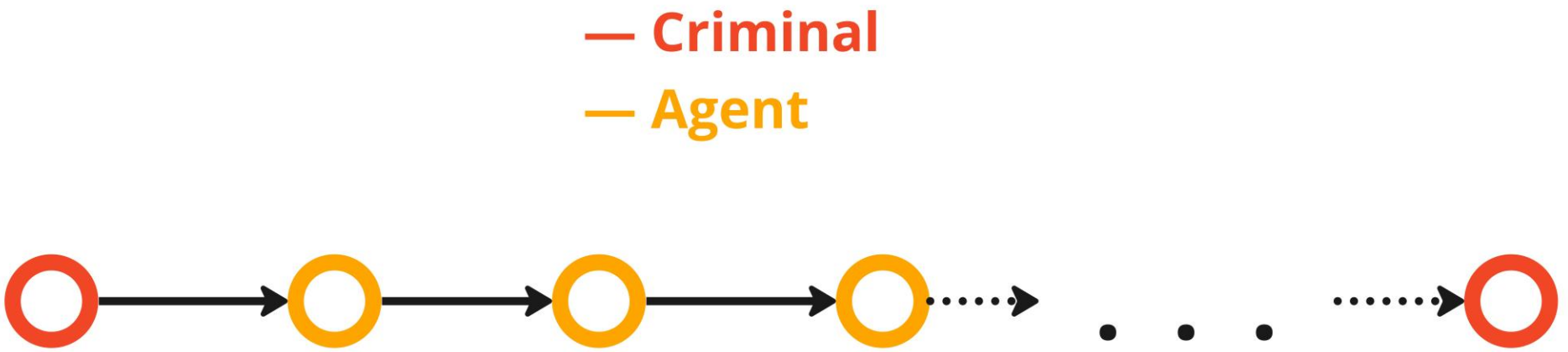
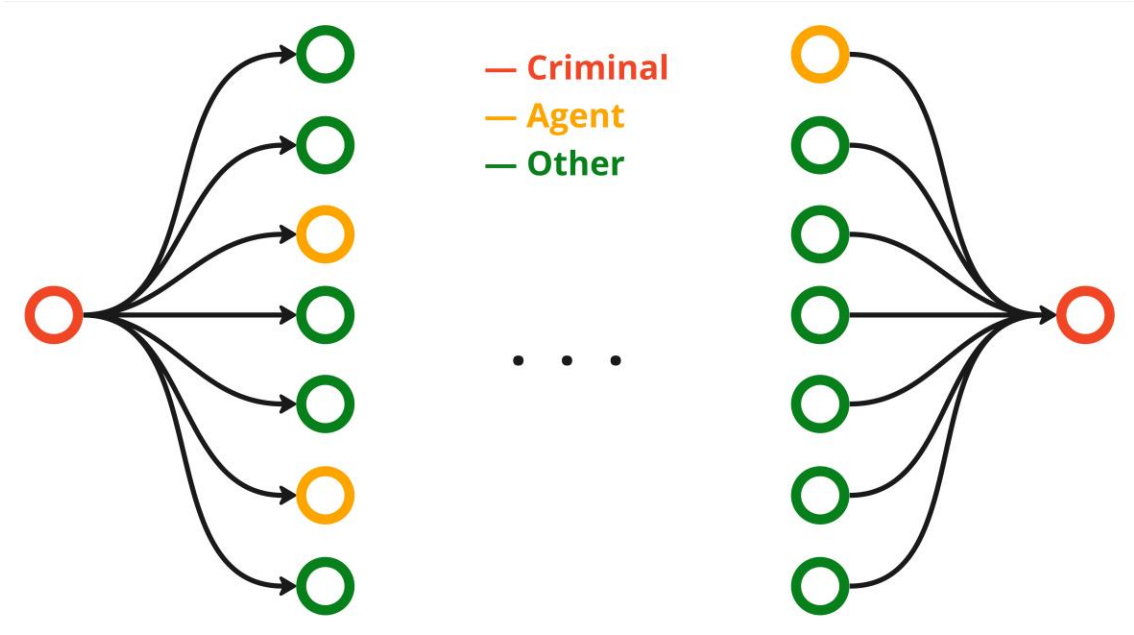


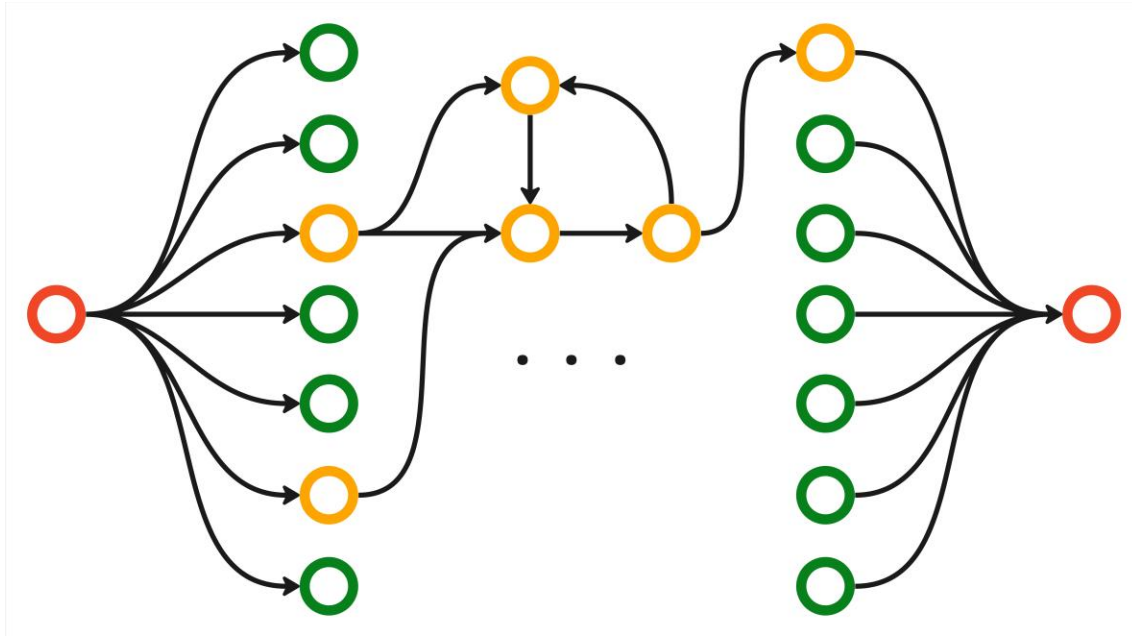
[Why Complicate] Transferring money via several hops



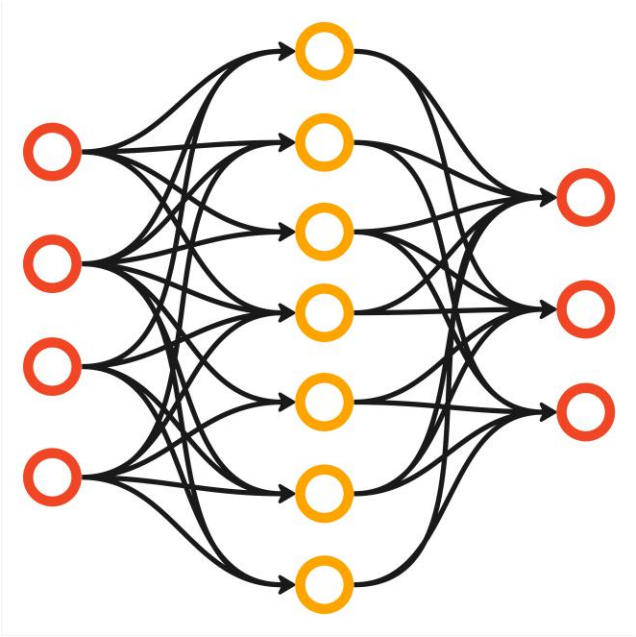
[Why Complicate] Few interactions with the accomplices



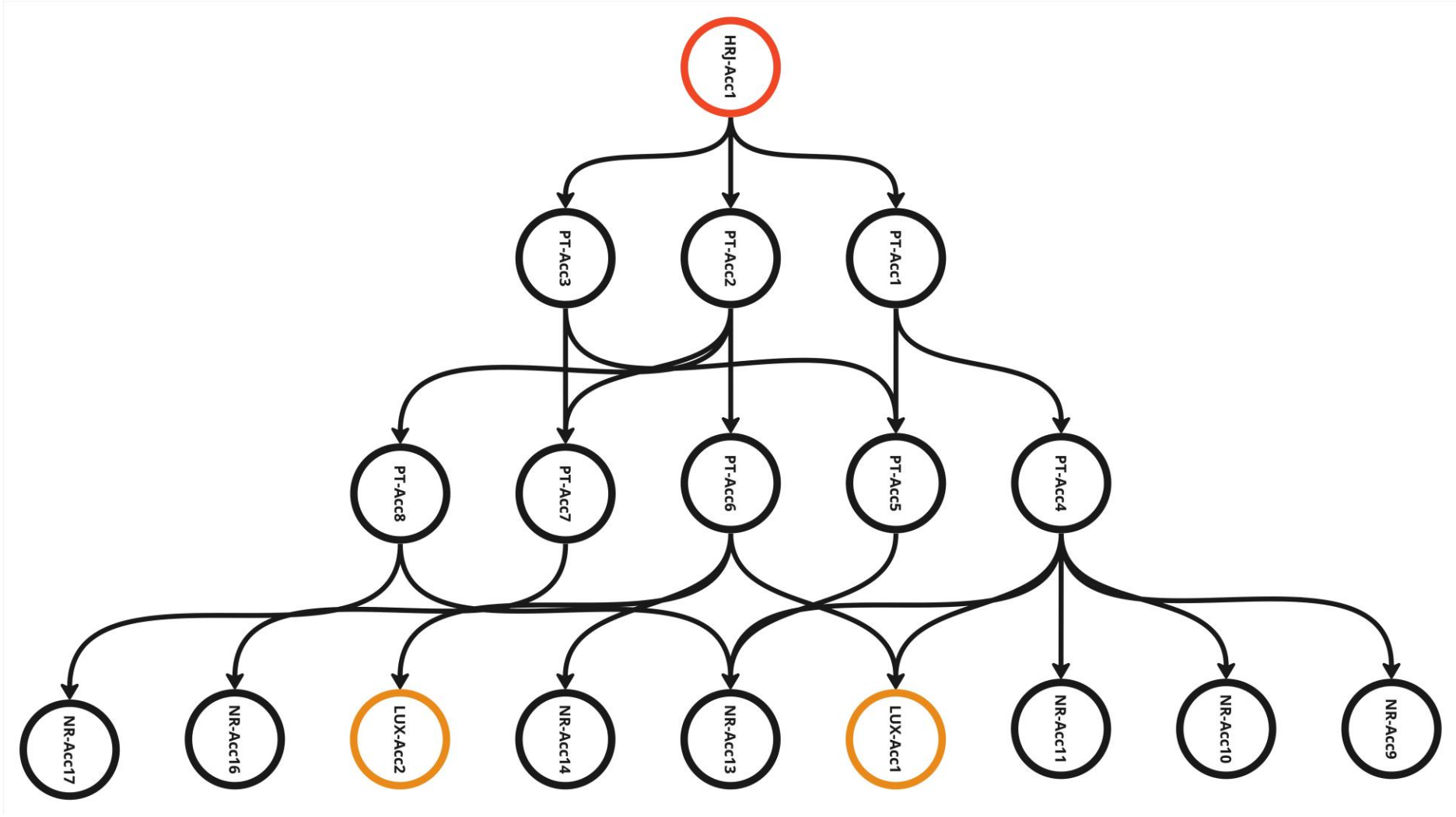
[Why Complicate] More interactions among the accomplices



[Why Complicate] Breaking down big transactions into many (small) transactions



Motif queries complexity



Limitations in existing methods

- Define start and end of a flow
- Define number of hops
- Every path has the same importance
- Naïve grouping of flows

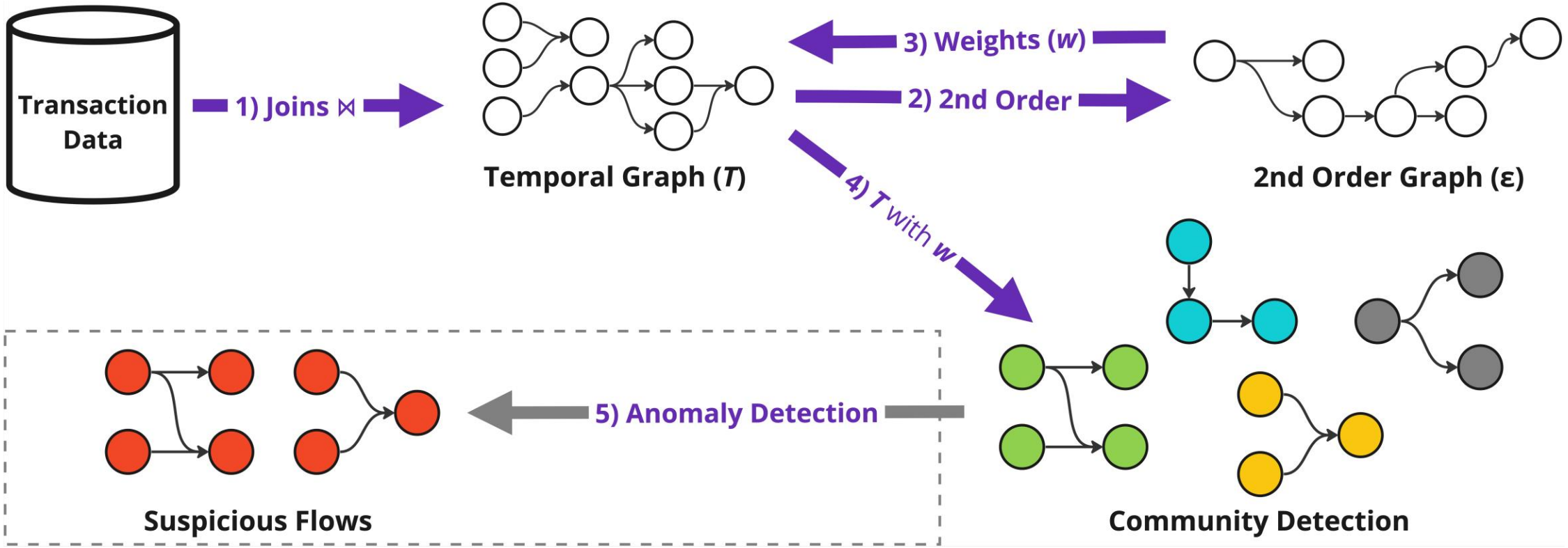
Limitations in existing methods

	Dynamic Grouping	Parameter-free for # of hops	Complex Flows	Suitable for multi-bank data
DBJ [28]	✗	✗	✗	✓
FlowScope [26]	✓	✗	✗	✗
FaSTM∀N (Ours)	✓	✓	✓	✓

Table 1: Features Comparison of State-of-the-art AML approaches and FaSTM∀N

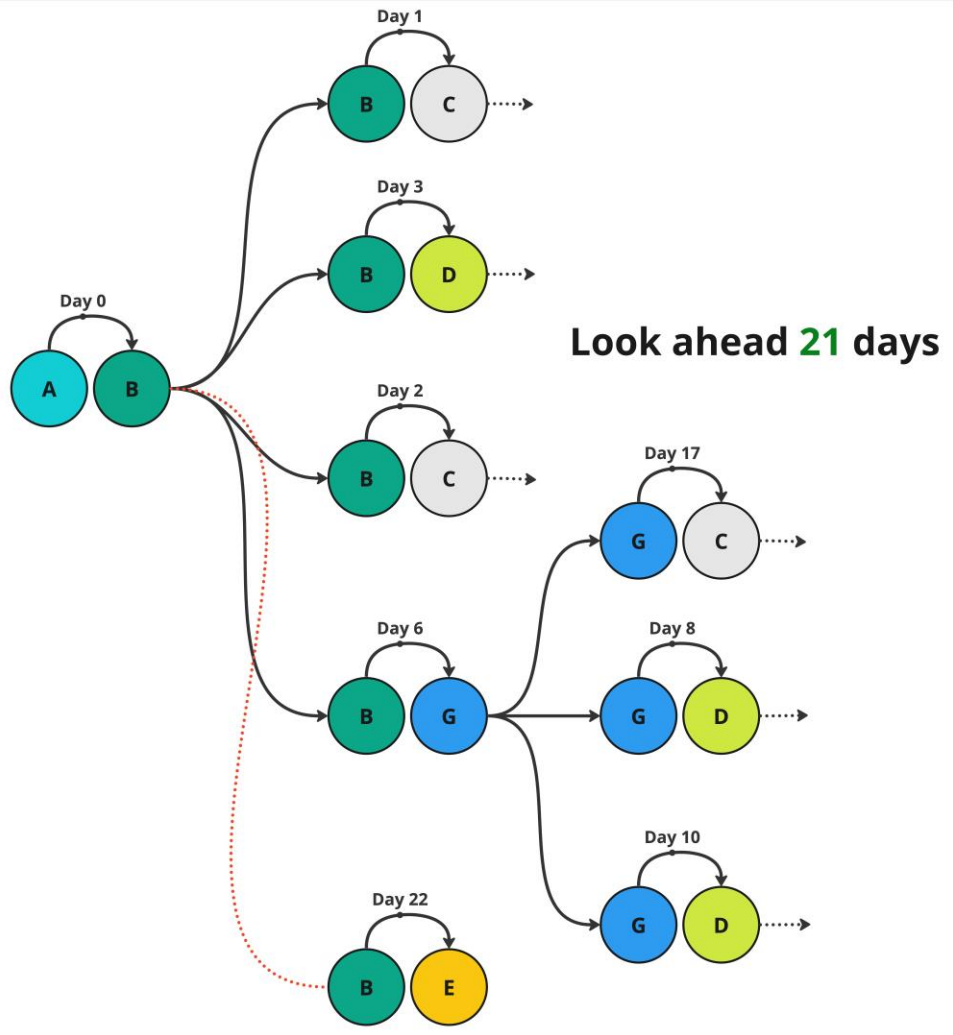
[28] Michele Starnini et al. "Smurf-Based Anti-money Laundering in Time-Evolving Transaction Networks", ECML PKDD 2021.
[26] Xiangfeng Li et al. "FlowScope: Spotting Money Laundering Based on Graphs", AAAI Conference on Artificial Intelligence 2020.

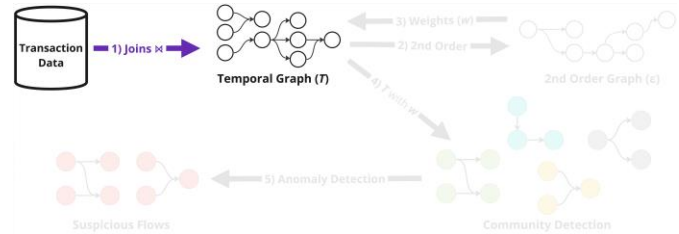
Framework diagram



[Method] 1) Joins

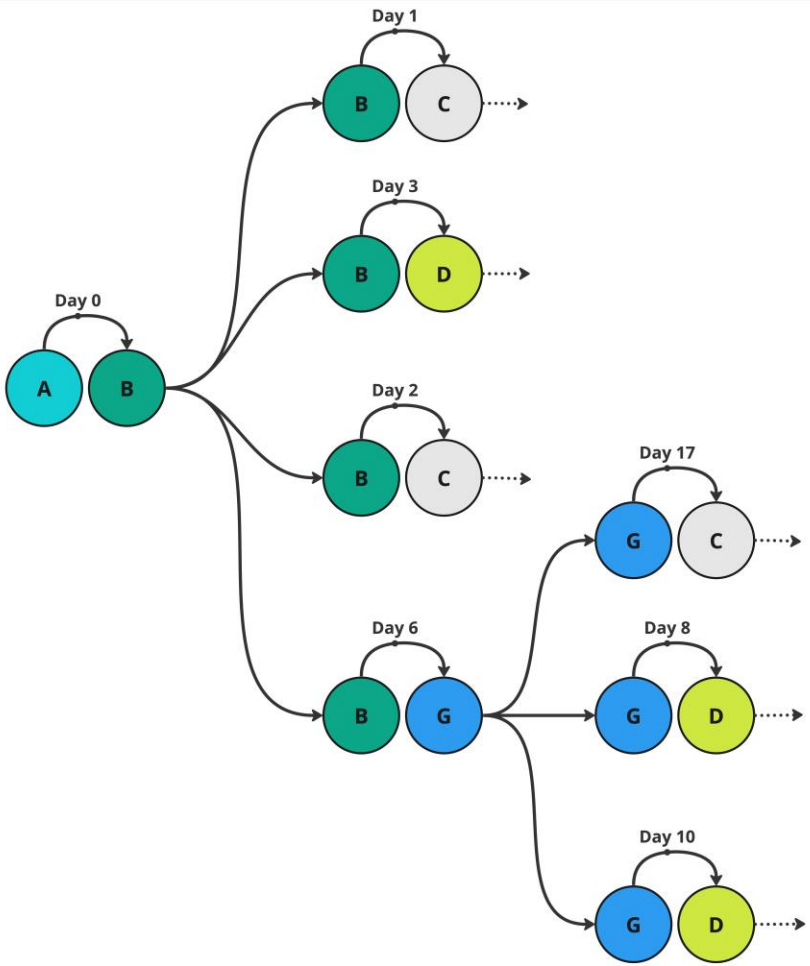
Connect every transaction to every other possible transaction

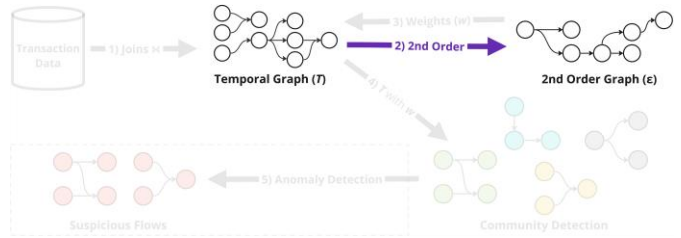




[Method] 2) 2nd Order

Quantify the connections





Definition 2 (Co-occurrence Weight). *Using $\mathcal{S}$, the co-occurrence weight between a source node $A \to B$ and a destination node $B \to C$ is calculated as,*

$$\mathcal{W}(A \to B, B \to C) = max(\mathcal{P}(A \to B, B \to C), \mathcal{P}'(A \to B, B \to C))$$

where,

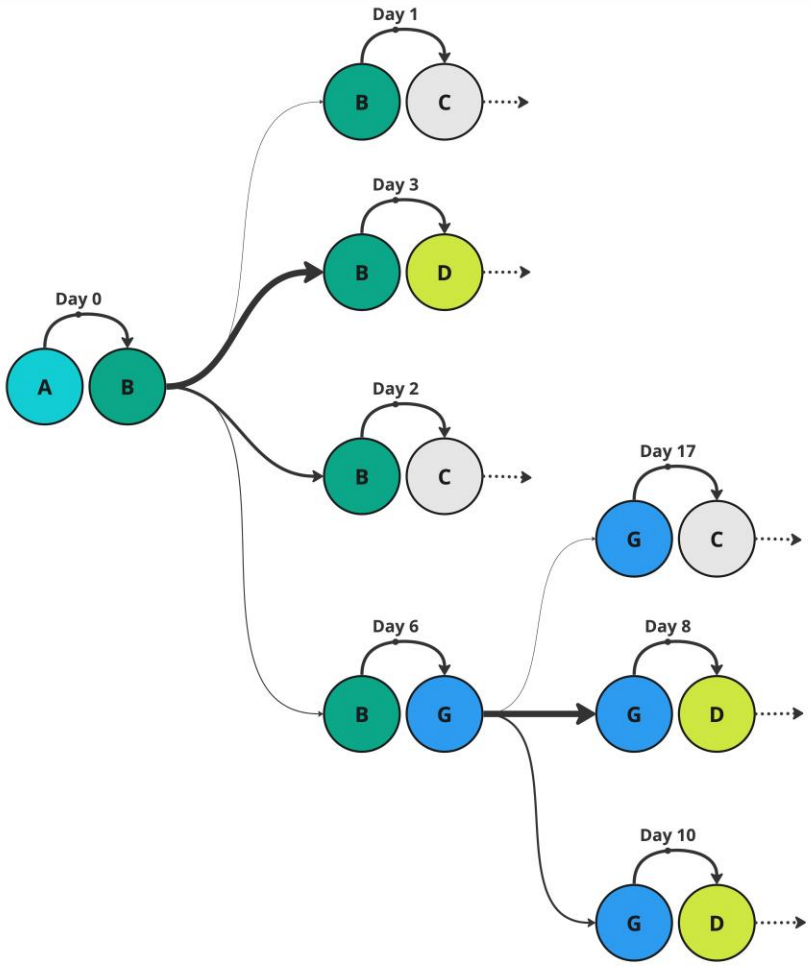
$$\mathcal{P}(A \to B, B \to C) = \frac{|\mathcal{S}(A \to B \sim B \to C)|}{|\mathcal{S}(A \to B \sim B \to [*])|}$$

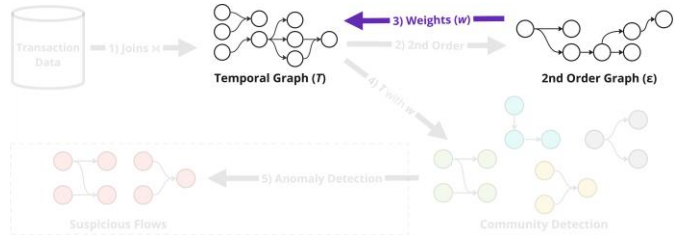
and,

$$\mathcal{P}'(A \to B, B \to C) = \frac{|\mathcal{S}(A \to B \sim B \to C)|}{|\mathcal{S}([*] \to B \sim B \to C)|}$$

*where, $[*]$ represents **any** account and $\sim$ represents directed adjacency from the left to the right node(s).*

Apply the weights



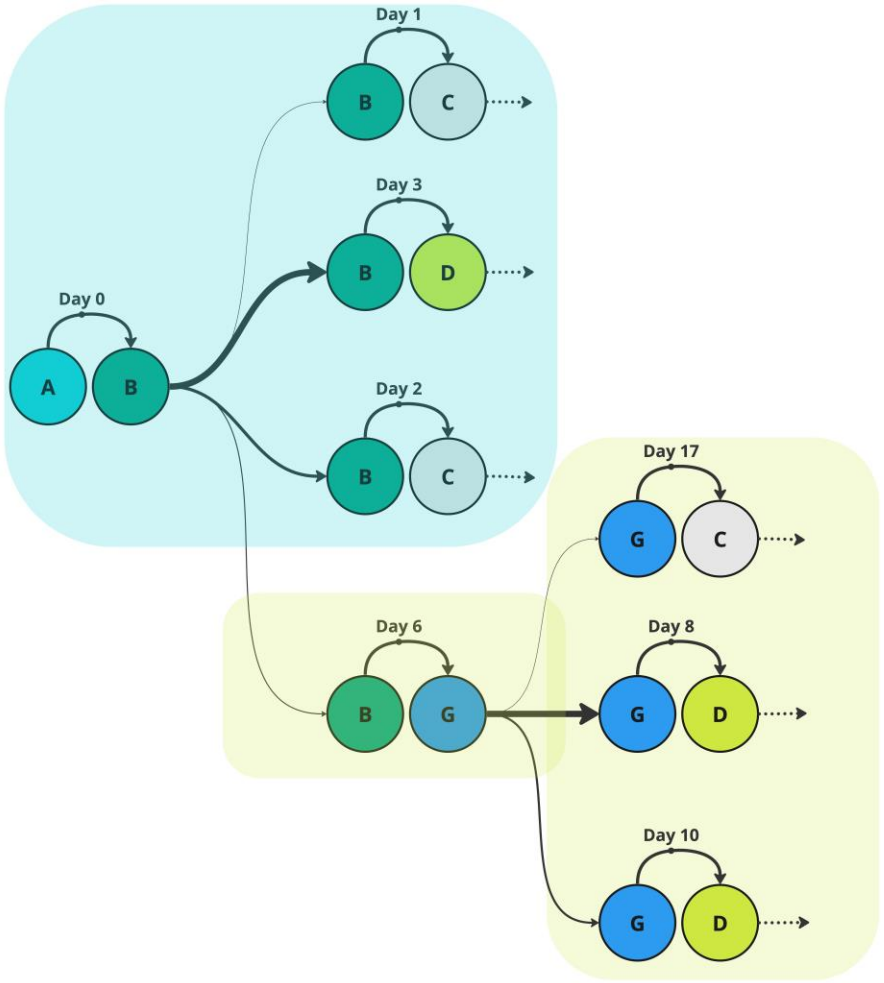


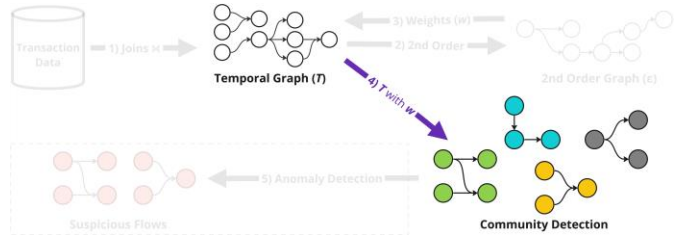
Source Perspective	
A→B	B→C
D→B	B→E
D→B	B→E
A→B	B→W
A→B	B→C
K→B	B→L
Z→B	B→T
Z→B	B→C
A→B	B→L
A→B	B→G
=	2/5

Destination Perspective	
A→B	B→C
D→B	B→E
D→B	B→E
A→B	B→W
A→B	B→C
K→B	B→L
Z→B	B→T
Z→B	B→C
A→B	B→L
A→B	B→G
=	2/3

```
= MAX(2/5, 2/3)
= 2/3
```

Detect communities of connected transactions

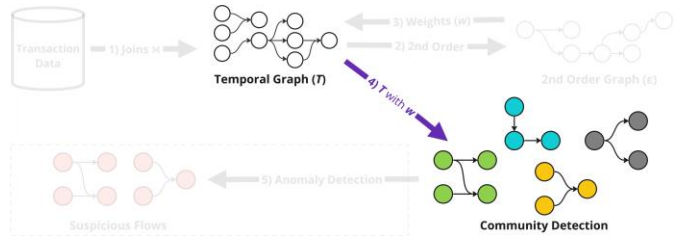




Vincent A. Traag, Ludo Waltman, and Nees Jan van Eck. “From Louvain to Leiden: guaranteeing well-connected communities”, Scientific Reports.

Detect communities of connected transactions

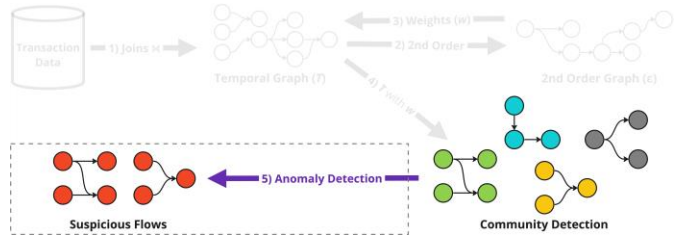
- Transactions that are *strongly* connected form a community



- If transaction-x appears in community-y
  - It will not appear in any other community
  - The other transactions in community-y have strong dependence on transaction-x
  - The transactions in other communities have weak(er) dependence on transaction-x

Marking communities of transactions as suspicious

- Max-flow based approach
  - Cash deposits as sources
  - HRJ deposits as sinks



- Graph level Anomaly Detection (GLAD)
  - Graph embeddings
  - Autoencoders
  - Isolation forest
  - …?

Follow all Suspicious Trails of Money *for all* Nodes (FaSTM∀N)

Space Complexity

Step	Transactions	$\mathcal{T}$ Edges
Initial state	1.1 billion	-
Pre-processing	510 million	-
$\mathcal{T}$ creation	475 million	25 billion
Remove weak edges	325 million	2.3 billion

Table 2: Space explosion and implosion after each step

Runtimes

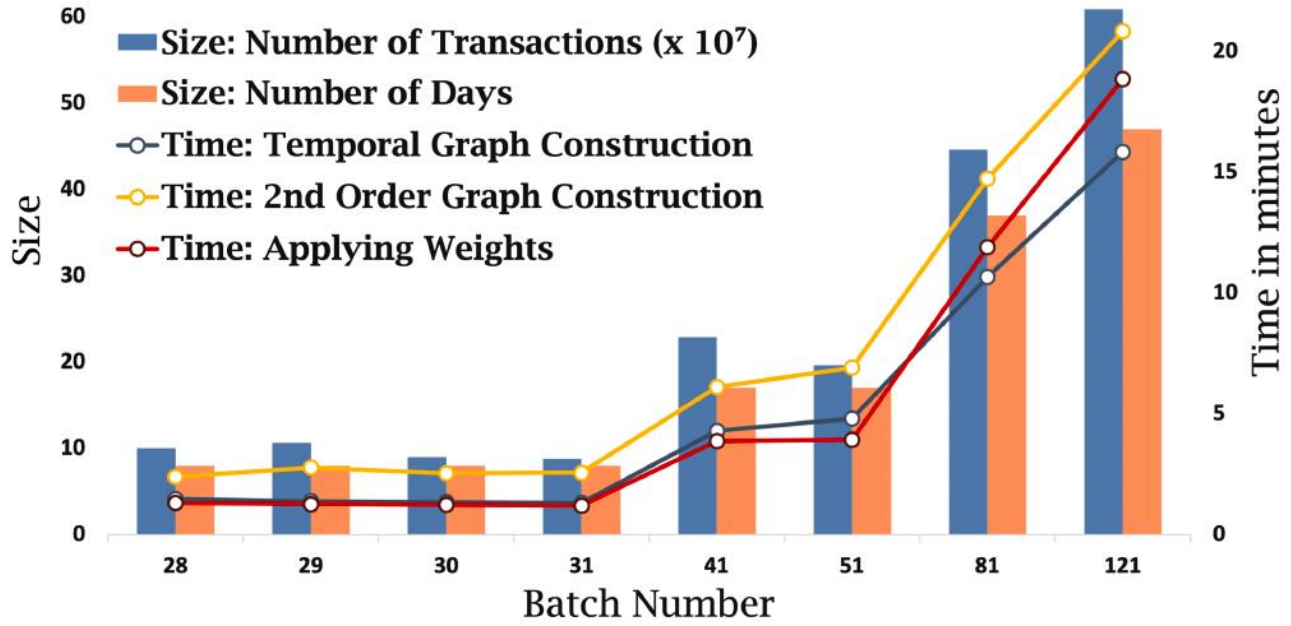


Fig. 8: Runtimes for batches with different number of days in the data

Functional and usability comparison

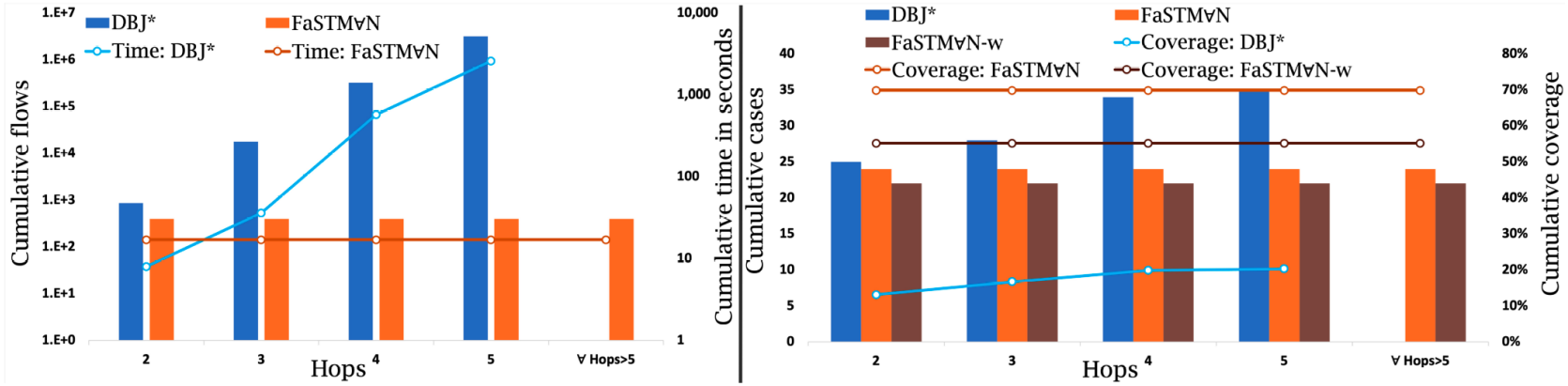


Fig. 10: Suspicious flow detection comparisons. (a) A comparison for runtimes. Both y-axes scales are logarithmic. (b) A functional comparison for the suspicious flows. Higher coverage with lower number of cases is the desired outcome.

[DBJ] Michele Starnini et al. "Smurf-Based Anti-money Laundering in Time-Evolving Transaction Networks", ECML PKDD 2021.

Topology-agnostic nature

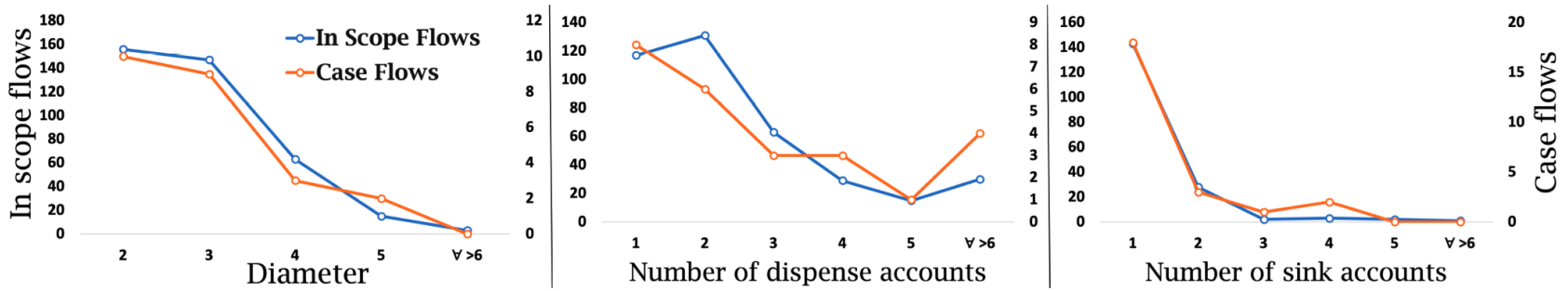


Fig. 11: Topological diversity of the flows

Functional and usability comparison

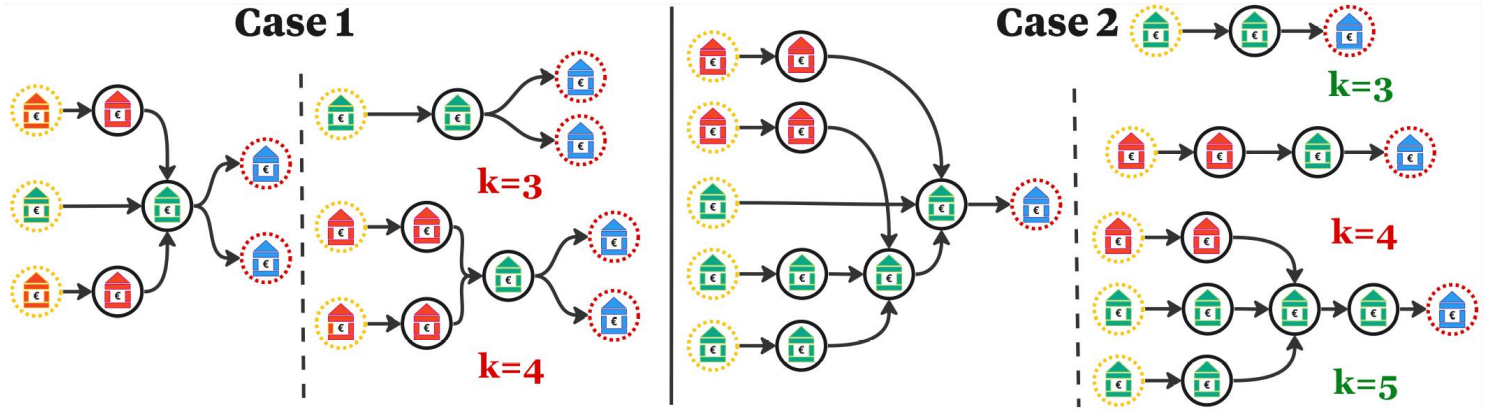


Fig. 12: Two cases of **real** flows. On the left of the dashed lines are the flows detected by FaSTM∀N, and on the right, the series of **separate** flows detected by FlowScope. The red font for k=x indicates that the flow was not flagged suspicious by FlowScope, based on risk criterion *C3*.

[FlowScope] Xiangfeng Li et al. "FlowScope: Spotting Money Laundering Based on Graphs", AAAI Conference on Artificial Intelligence 2020.

Future work and improvements

- Using higher (> 2nd) order or multi-order representations may reveal more interesting relationships
- Experimentation with the edge weights is important based on business problem – you are looking to capture meaningful relationships based on what you deem important for the modus operandi
- Community detection
  - Based on recurring flows, over different periods of time, detect communities of entities
- Targeted network search
  - Return all the dominant flows a query account is involved in

Questions

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  - https://mhaseebtariq.com/
- m.hassani@tue.nl
- Transaction Monitoring Netherlands (TMNL)
  - https://tmnl.nl/

- https://github.com/mhaseebtariq/fastman