GRAPH FOR ALL

MILLION DOLLAR CHALLENGE

TigerGraph

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Graph For A Better Token Economy

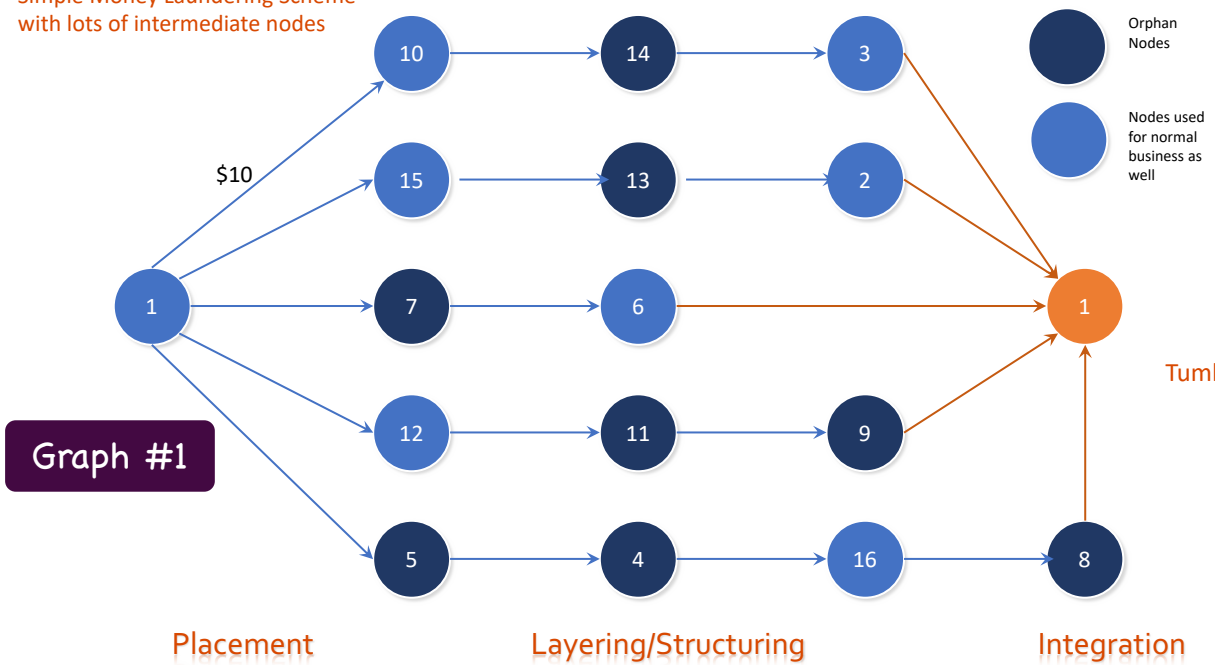
- **Problem Statement**
  - Immutable, Distributed, Unanimous & *Secure* DLT & Blockchain stack for Crypto currency & Web 3.0
    - While the other properties are well implemented, security is still a challenge
  - Specifically, this project addresses the detection of Fraud Rings (e.g., Money Laundering) & Camouflaged Fraud (e.g., Fake Product Reviews)
- **Hypothesis**
  - Graph representation & algorithms are well suited to extract fraud rings of *arbitrary complexity*
- **Approach**
  - Tackle one of the complex fraud pattern in a scalable, extensible way

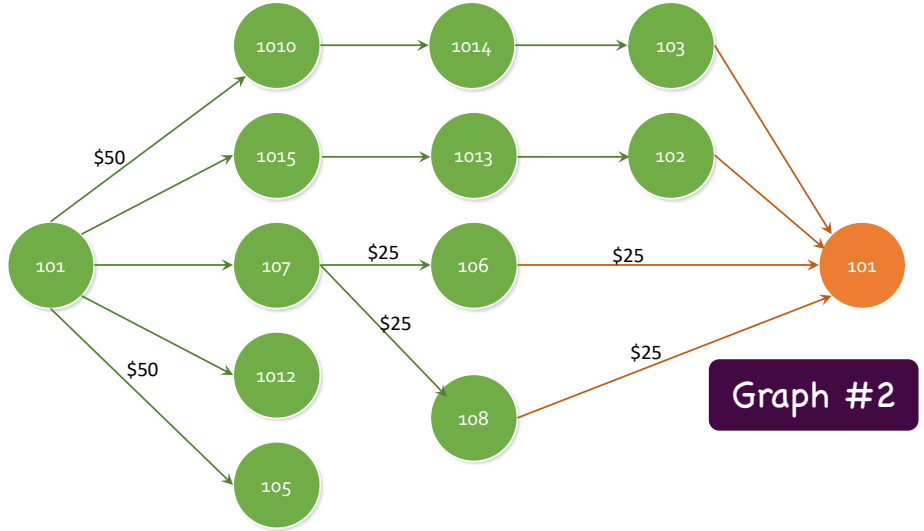
Fan-In/Fan-Out Fraud Rings

- Money Laundering goes through 3 stages viz Placement, Layering and Integration
- Layering is the most complex, where the money is piped through a complex web of strategic transactions – mixers, tumblers, long chain of crypto transactions et al., obscuring the money trail
- As we will see later, one essential aspect in understanding the problem is to draw representative graphs – *the happy path 1st* (see next slide)

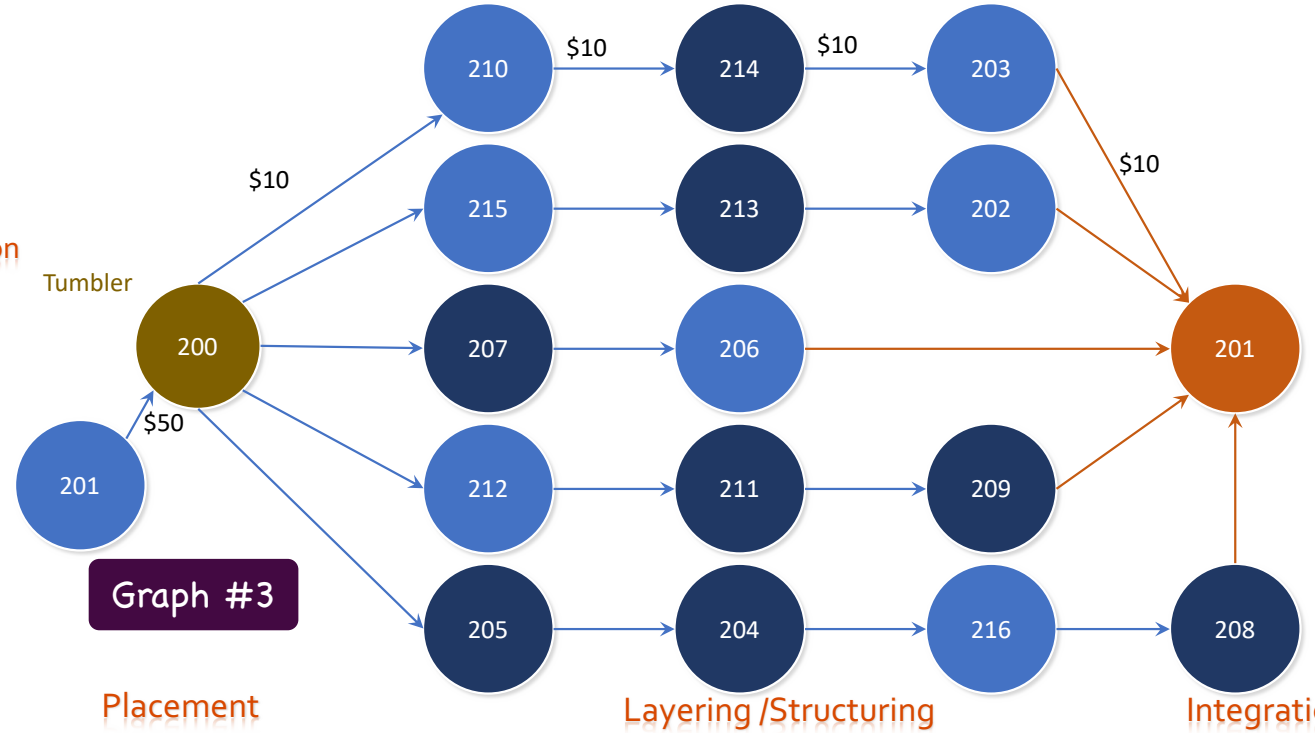
Money Laundering Graphs

Simple Money Laundering Scheme
with lots of intermediate nodes





Tumbler Network Money Laundering Scheme



Challenges

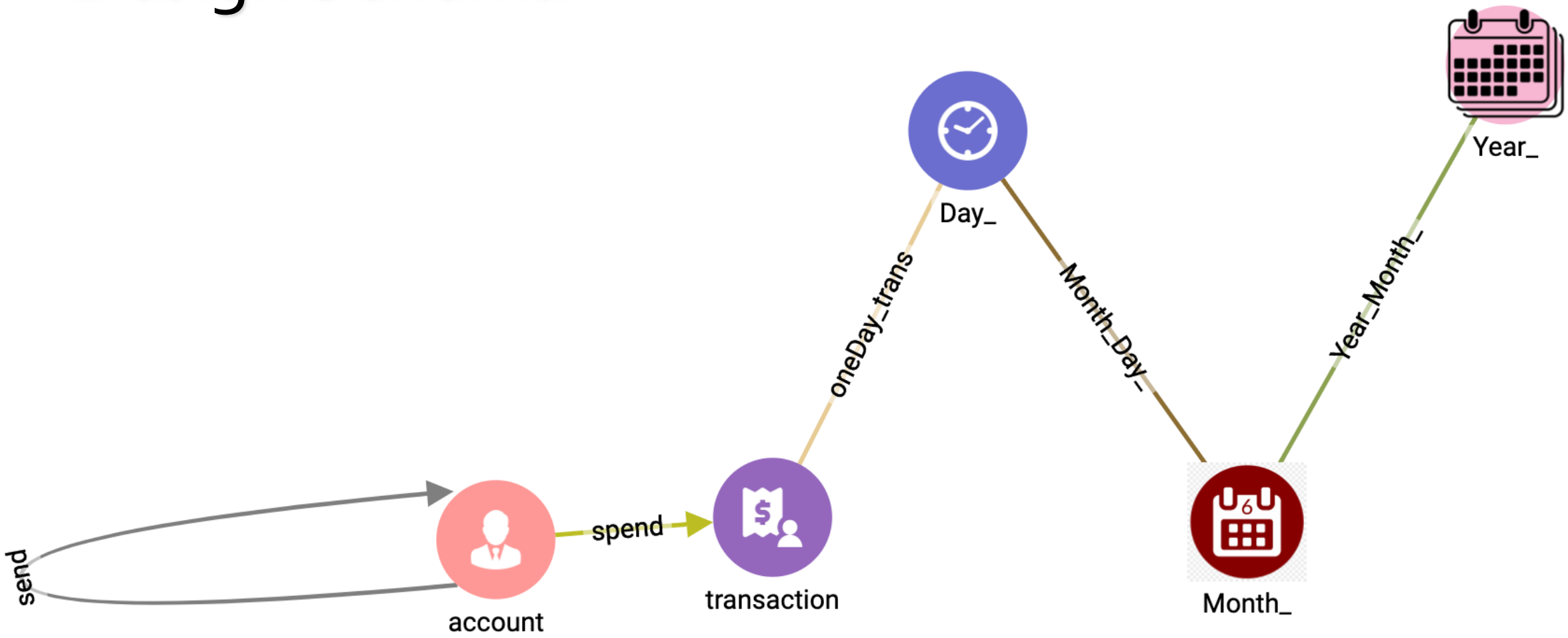
1. Payment network is very different from social or other networks
   - Temporal, monotonic time
   - Not symmetric
   - Other attributes (like amount) matters
   - Many of the concepts like connected components and page rank do not mean much
2. Money Laundering Layering is not just one cycle
   - But multiple ordered cycles with a fraud actor at the helm
3. Detecting fraud ring is literally finding the proverbial needle in a haystack
   - Class imbalance, Long Fraud Chains

Approach

1. Layered approach with well defined pipeline stages
   - *Overlay fraud rings progressively*
   - *Narrow down and organize the vertices as we progress*
   - *Always keep time sequencing in the processing*
2. Customize relevant gsql graph algorithms
   - *e.g., Rocha-Thatte Cycle Detection, but it is unordered*
   - *Also need to combine cycles and find the fraud actor at the helm*
3. Add runtime attributes to vertices
   - *That will help the processing downstream the pipeline*
4. Start with a simple schema and add more elements as required
5. Stay in TigerGraph as much as possible

Demo

Design Schema

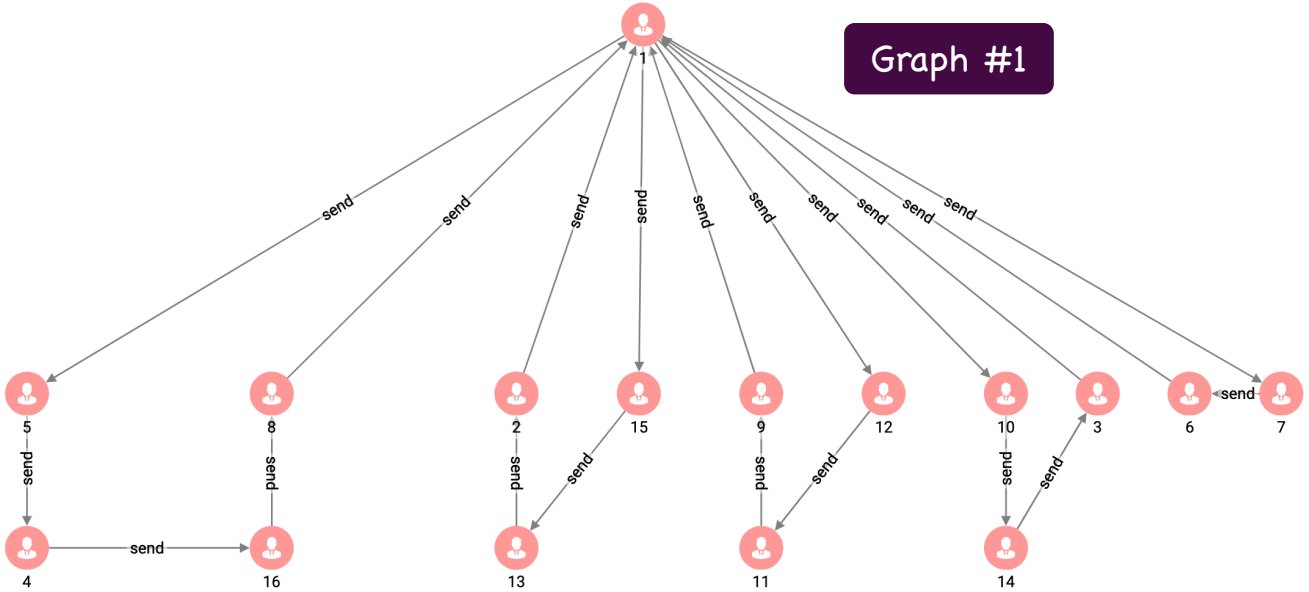


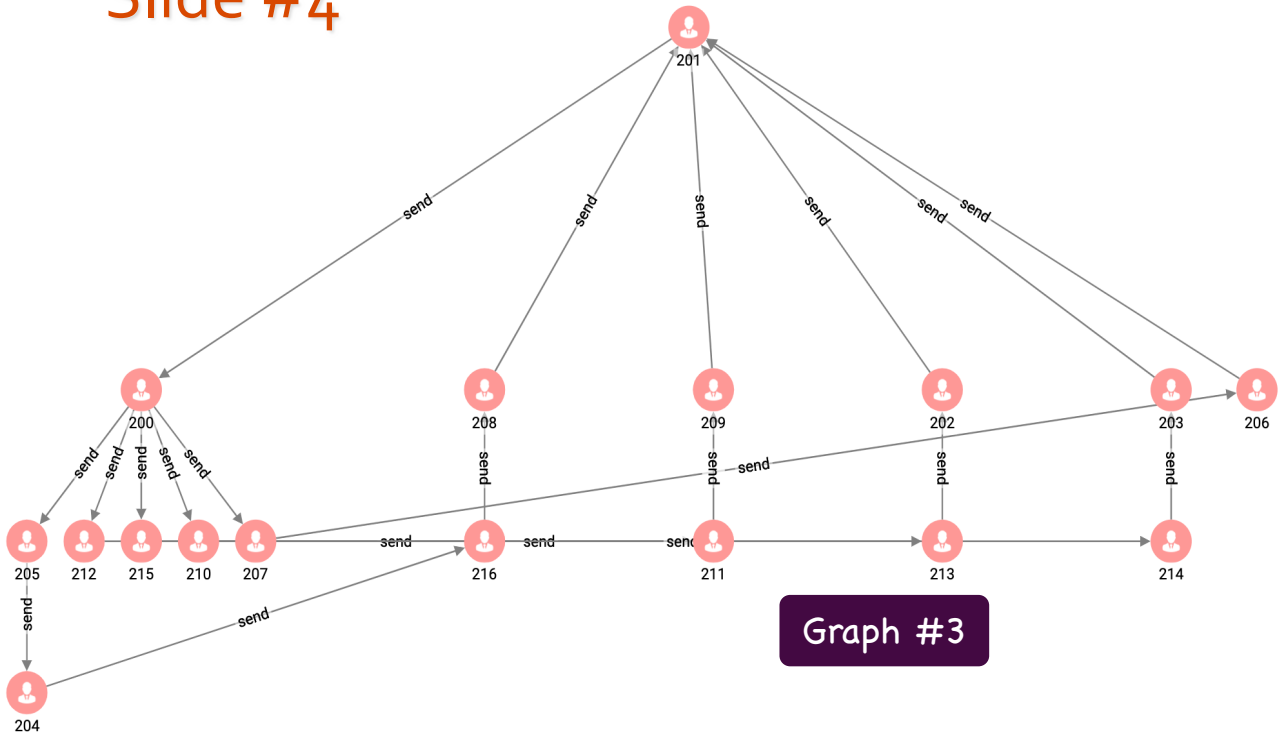
Schema Information

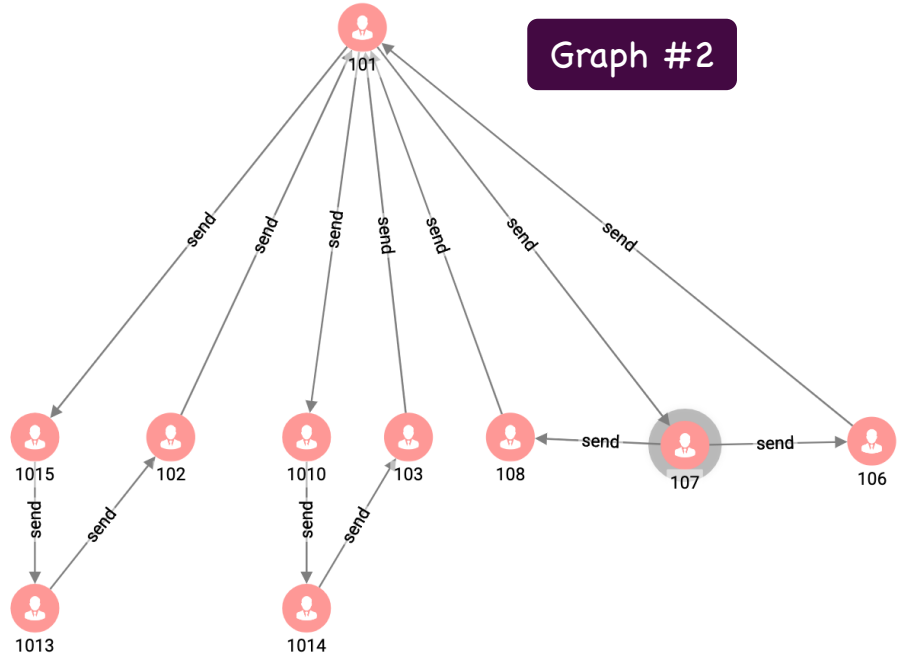
- Vertex information:
  - Vertex: account
    - (PRIMARY ID) id: STRING
    - v_type: INT
  - Vertex: transaction
    - (PRIMARY ID) id: STRING
    - amt: DOUBLE
    - date_time: DATETIME
    - from_id: UINT
    - to_id: UINT
  - Vertex: Year_
    - (PRIMARY ID) id: STRING
  - Vertex: Month_
    - (PRIMARY ID) id: STRING
  - Vertex: Day_
    - (PRIMARY ID) id: STRING
- Edge information:
  - Edge: send
    - Source: account
    - Target: account
    - amount: DOUBLE
    - date_time: DATETIME
  - reverse edge: reverse_send
  - Edge: spend
    - Source: account
    - Target: transaction
  - reverse edge: reverse_spend
  - Edge: Year_Month_
    - Source: Year_
    - Target: Month_
  - Edge: Month_Day_
    - Source: Month_
    - Target: Day_
- Edge: oneDay_trans
  - Source: transaction
  - Target: Day_
  - date_time: DATETIME

Output

- It finds all the 3 fraud rings !
- And, correctly identifies the fraud actors at the helm
- You can compare with Slide #4







Lessons Learned

1. Graph representation is appropriate for DLT/Blockchain Fraud Detection
   - *TigerGraph is a feature rich, flexible & scalable Graph Database well suited for this problem*
   - *But it requires disciplined thinking, at times different than what we are used to !*
2. Spend time thinking about & understanding the problem
3. Make simplified assumptions and relax them as you progress (Layered approach)
4. Think Graphs & more specifically Parallel Graphs – It will take a little time to get used to that concept
   - *Read, write & learn the patterns from the GSQL Graph Algorithms and the GSQL code*
5. Draw graph diagrams to visualize the problem - *Draw the happy path 1st & then edge cases*
6. Create datasets depicting multiple scenarios – *1st use a small dataset to test the algorithms*
7. Do as much in TigerGraph as possible
   - *It is tempting to process a list outside (say in python), after a quick GSQL algorithm; don't stop there, persist (using GSQL) until you have exhausted all graph ideas*

Things To Try Next … *This is only the beginning !*

1. Scale ! Load Bitcoin/Ethereum blockchains and apply the algorithms
   - *Cross-Ledger tracking of fraud rings*
2. Fine grained temporals
   - *There could be many such rings by the same actors, so need to separate the rings by time*
   - *solution : time tree "If you need to filter use vertices" – TigerGraph pragma*
   - *Opportunity for Payment Networks in TigerGraph Graph Algorithms*
3. More expressive Graph schema with derived runtime attributes, especially to track cross-ledger behaviors
4. Explore Graph Motif extraction, Weighted Graphs
5. Graph Neural Networks leveraging the extended dynamic attributes
6. Entity Resolution
   - *Need to understand heavy spans & differentiate between Exchanges, Tumblers, Mixers - Add Vertex type based customized logic*
   - *Probably via highest measure of eigenvalue centrality*