

# Presentation Title

## Optional Subtitle

K. Cong

Faculty of Electrical Engineering, Mathematics and Computer Science  
Delft University of Technology

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# Outline

## Background

- TrustChain

## My Thesis

- TrustChain with Checkpoints

- Protocol Overview

- Promoter Registration

- Consensus

- Validation

- Implementation and Experimentation Results

# Outline

## Background

TrustChain

## My Thesis

TrustChain with Checkpoints

Protocol Overview

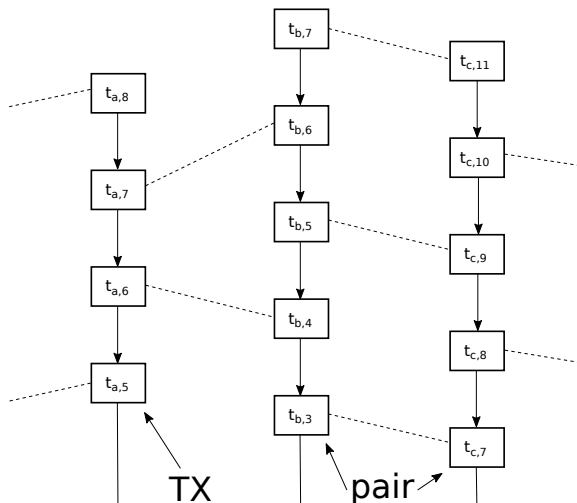
Promoter Registration

Consensus

Validation

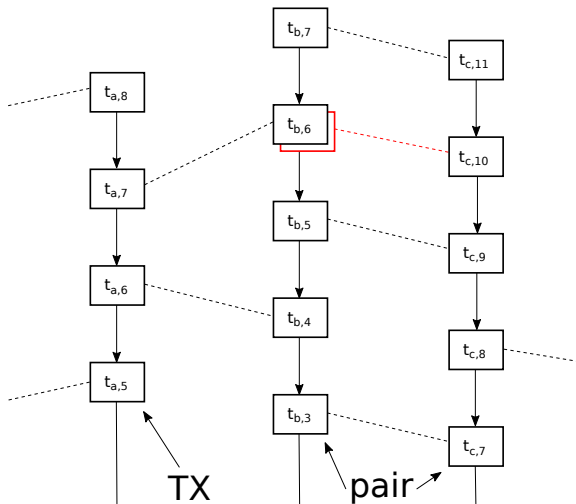
Implementation and Experimentation Results

# TrustChain



**Figure:** Every node has a chain. *TX block* is a six-tuple:  
 $t_{i,j} = (h(b_{i,j-1}), h_s, h_r, s_s, s_r, m)$ , one transaction results in two TX blocks—a *pair*.

# TrustChain



**Figure:** Fork is two correctly signed TX blocks that belong to the same sender and has the same hash pointer but involve different receivers. Only one TX block may be in consensus.

# TrustChain

- ▶ Everyone has their own chain
- ▶ Transactions are on arbitrary data  $m$
- ▶ Transactions are irrefutable due to hash pointers
- ▶ No consensus (my thesis)

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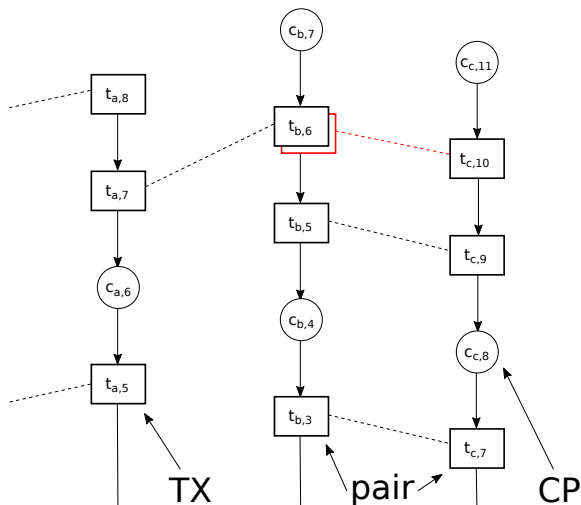
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# TrustChain with Checkpoints



**Figure:** CP block is a six-tuple:  $c_{i,j} = (h(b_{i,j-1}), h(C_r), h, r, p, s)$ ,  $C_r$  is the consensus result at round  $r$ ,  $p$  = promoter indicator,  $s$  = signature.



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# Protocol Overview

1.  $n$  lucky nodes are selected at random to act as promoters.
2. Promoters run a BFT (Byzantine Fault Tolerant) consensus algorithm to agree on a set of CP blocks.
3. Disseminate the consensus result (the CP blocks).
4. Repeat for next round.
5. Any interested node can validate that their transaction.

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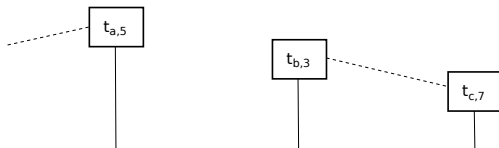
**Promoter Registration**

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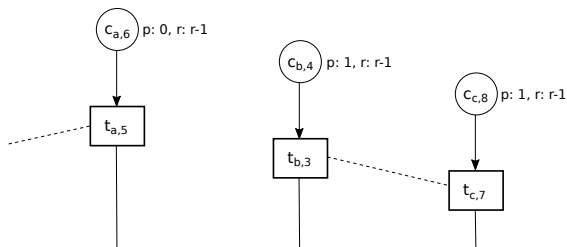
Implementation and Experimentation Results

# Promoter Registration



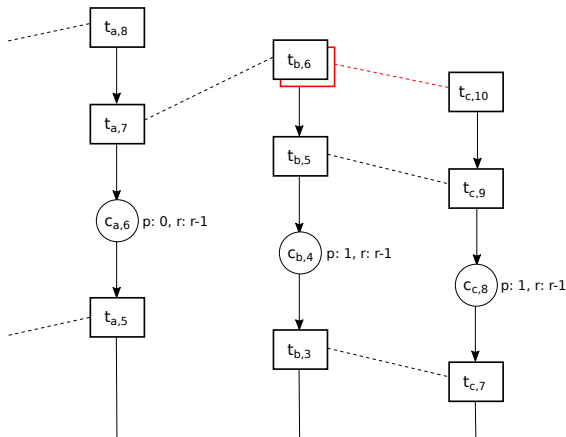
**Figure:** We start in the state where  $\mathcal{C}_{r-1}$  has just been agreed but not yet propagated.

# Promoter Registration



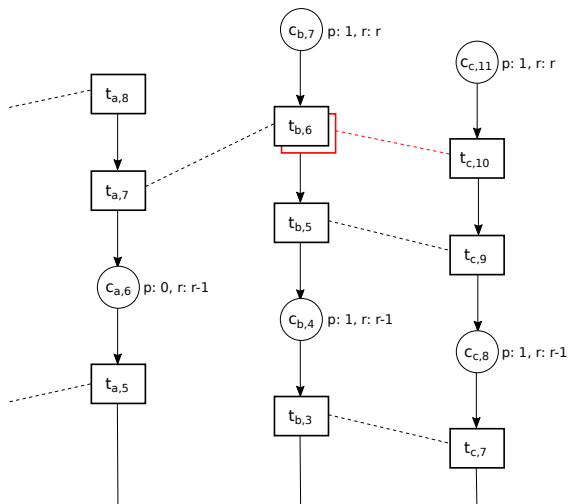
**Figure:** Nodes receive consensus result and set promoters indicator  $p$ , then send the new CP blocks to promoters of round  $r$ .

# Promoter Registration



**Figure:** Transactions carry on as usual in round  $r$ . Note that our CP blocks (round  $r - 1$ ) has not reached consensus yet.

# Promoter Registration



**Figure:** CP blocks at round  $r - 1$  should be in  $\mathcal{C}_r$ . If we're lucky:  $h(k_i || c_{i,j}) < T$ , then we're responsible for consensus of round  $r + 1$ .

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# Consensus

1. Nodes send CP blocks to the promoters.
2. The promoters' identities are encoded in the consensus result.
3. Promoters run the same asynchronous BFT consensus algorithm to agree on a set of CP blocks— $\mathcal{C}_r$ .
4.  $n \geq 3t + 1$  is the optimal for BFT consensus.
5.  $\mathcal{C}_r$  and the signatures are disseminated.
6. Nodes create new CP blocks when they receive  $t + 1$  good signatures and  $\mathcal{C}_r$ .

## Theorem

*Assuming the promoters satisfy  $n \geq 3t + 1$ . The promoter registration and the consensus protocol satisfies agreement, total order and liveness.*

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# Validation

Assume node  $u$  is aware of all the past consensus results  $\mathcal{C}_r$ . Suppose  $u$  wish to validate  $t_{i,j}$ . It performs the following.

1. Determine the pair  $t_{i',j'}$ .
2. Find the agreed enclosure for  $t_{i,j}$  and  $t_{i',j'}$  from  $\mathcal{C}_r$ , otherwise return “unknown”.
3. Query  $i$  and  $i'$  for the agreed pieces and ensure hash pointers are correct. Otherwise return “unknown”.
4. Check that  $t_{i,j}$  and  $t_{i',j'}$  are in the agreed pieces and are created correctly using `newtx`. Otherwise return “invalid”.
5. Check the checkpoints  $c_{i,k}$  and  $c_{i',k'}$  that immediately follow  $t_{i,j}$  and  $t_{i',j'}$  are in the agreed pieces and are created in the same round, i.e.  $\text{round}(c_{i,k}) = \text{round}(c_{i',k'})$ . Otherwise return “invalid”.
6. Return “valid”.

# Validation

In essence, given a TX, ask the receiver to proof that it has a set of transactions that produces some CP block, the CP block should be in the consensus result and the pair of the TX should be in that set.

## Theorem

*If at least one party of every transaction is honest, then forking and other forms of tampering is guaranteed to be detected if the malicious party is alive.*

## Question

Given a starting digest and an ending digest, is it possible for the prover to proof to the verifier that it has a set of blocks linked by hash pointers that “fits” inside those digests in *zero knowledge*.

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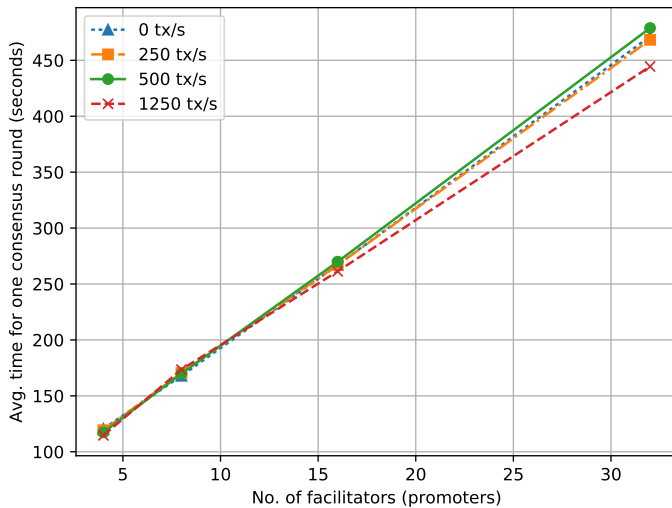
# Implementation (4 weeks ago)

- ▶ Currently on going—using Python and Twisted
- ▶ Completed BFT consensus algorithm
- ▶ Completed local TrustChain with Checkpoints
- ▶ Next step is networked TrustChain and validation protocol

# Implementation

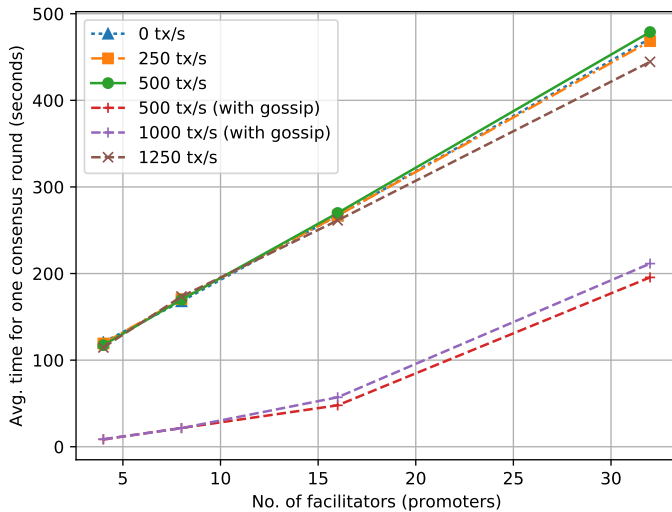
- ▶ Completed BFT consensus algorithm, with erasure coding
- ▶ Completed TrustChain with Checkpoints, with experiments on DAS5
- ▶ Validation function is working
- ▶ Next step is to build validation into a network protocol and do experiments

# Experiment with 500 nodes—no gossip





# Experiment with 500 nodes—with gossip



# Experiment with 500 nodes—with gossip

## Conclusion

- ▶ The number of facilitators affects the consensus latency ( $O(N \log N)$ ?).
- ▶ The transaction rate has little or not effect on the average consensus latency.

# Planned experiments

- ▶ Consensus latency (y-axis) vs population size (x-axis)—to investigate how population size impacts consensus latency.
- ▶ Global transaction rate vs population size—to investigate the scalability property.
- ▶ Global validation rate vs population size—to also investigate the scalability property.