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Transaction-based Configuration Management for Mobile Networks

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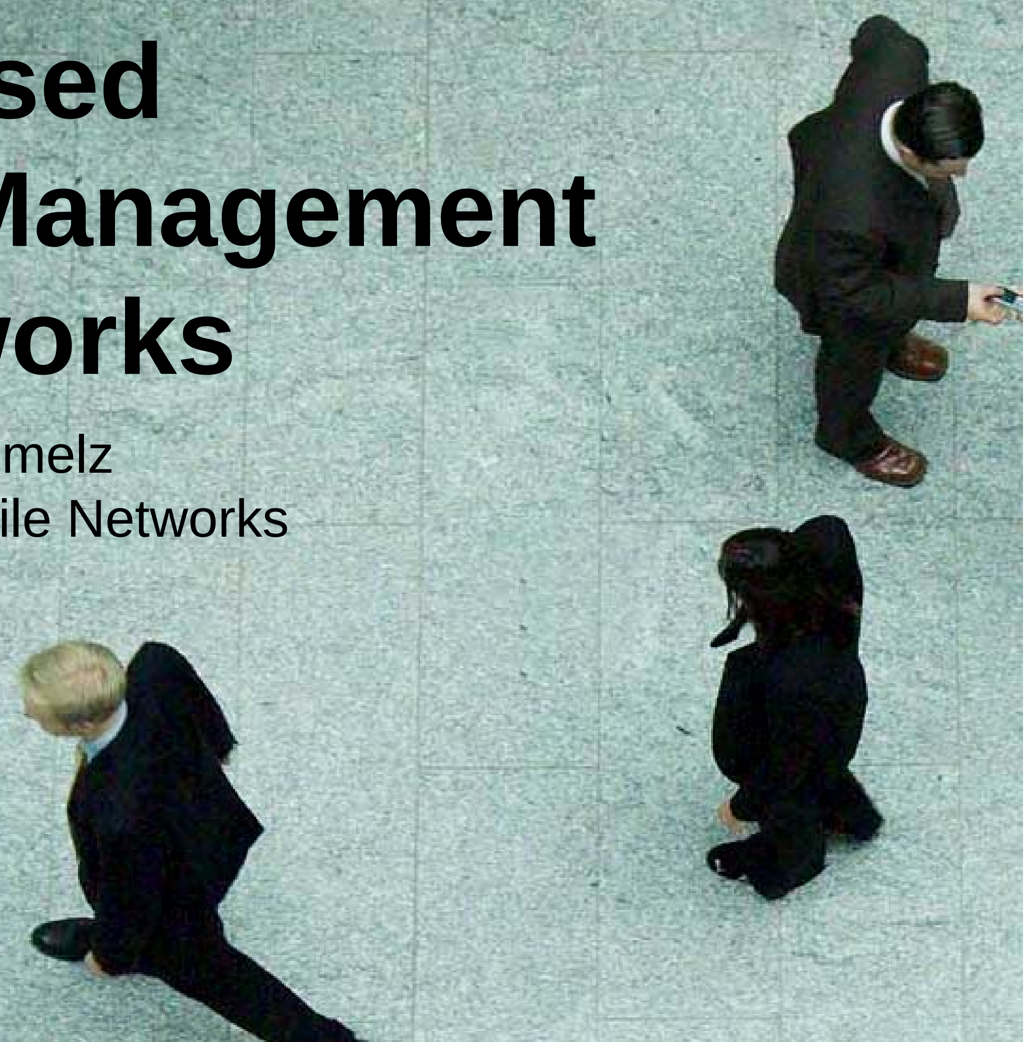

Outline

Goal

- Automated assurance of network-wide configuration data consistency

Use cases: Network optimization and growth

- Example: cell adjacency management

Proposed solution:
Transaction-oriented CM data management subsystem

- Integration into the element management architecture

Conclusions

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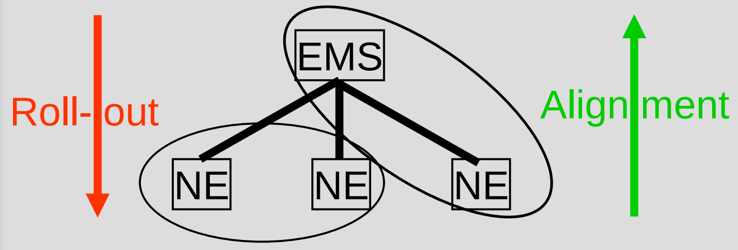
General problem statement

Requirement for an element management system (EMS):

The consistency of configuration data

- Between NEs and EMS
- Between NEs (dependencies)

needs to be assured at all times.



Error sources	*Description*
Non-ideal system components	O&M network links: limited bandwidth, link interruptions NEs may fail
Concurrency	Multiple sources of configuration changes (planning, multiple operators, local changes)
Limited roll-out time	Service-affecting configuration changes can only be rolled out during defined time windows (night hours, weekends)

Logical errors	Misconfiguration (human factor)

→(Automated) rollbacks from inconsistent NE/network states must be possible →**Transactions**

Specific problem statement for RAN Configuration Management (3G / 3G evolution)

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Category	*RAN CM property*	*Requirements to a full solution*
Roll-out phase	Few dependencies* comprising only small NE groups, but crucial and existent in numerous NE	Assurance of inter-NE consistency with adaptive commit strategy (not just 2PC**)
	Current management protocols: inefficient for delta configuration	Transaction-oriented protocol
	NEs need to function autonomously ("NE is the master of its data"), but no atomic operation at NE	Transactions at NE (& EMS) level
	Lack of speed	Parallelization of transactions
Alignment phase	Bulk alignment → reduced up-to-dateness	Delta alignment
Non-functional properties	Low O&M link bandwidth (Node B today: 128 kbit/s)	Bandwidth efficiency
	O&M link on microwave (Node B); planning / operator / local configuration changes	Robustness, "online" assurance of consistency
	Numerous NE	Scalability
	Manual work (NE configuration) in case of errors (→ downtime)	Efficiency through automation (network configuration)

* Dependencies: cell handover adjacencies, transport connections; future: security information

** 2PC: Two-phase commit: *all* NE of a group signal "ready to commit"; EMS triggers commit

Use cases in RAN Configuration Management (3G / 3G evolution)

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Network optimization (Prio 1):

- Large radio network plan update
  - Example: regular plan exchange (monthly), e.g., to improve load balancing among RNCs (radio), minimize leased line expenditures (transport), accommodate changed user requirements due to an upcoming event
- Manual update of radio network covering multiple NE
  - Examples: correct radio configuration deficiency covering several RNCs, reconfiguration of a Node B cascade

Network growth (Prio 2):

- Addition / rehoming of Node Bs(attention of human operator required anyway, support useful)

Assumptions for the evolution of the use cases:

- Distribution: numerous NE involved in CM (3G LTE), increasing number of NE
- Dynamics: more frequent reconfiguration of NEs to satisfy changing user demands (enabler: remote electric antenna tilting) → >1 network plan per network, change of plan over time (of day, of year)
- Diversity: integrated heterogeneous access networks (3G/3G LTE/WiMax)

Example workflow for adjacency management: today

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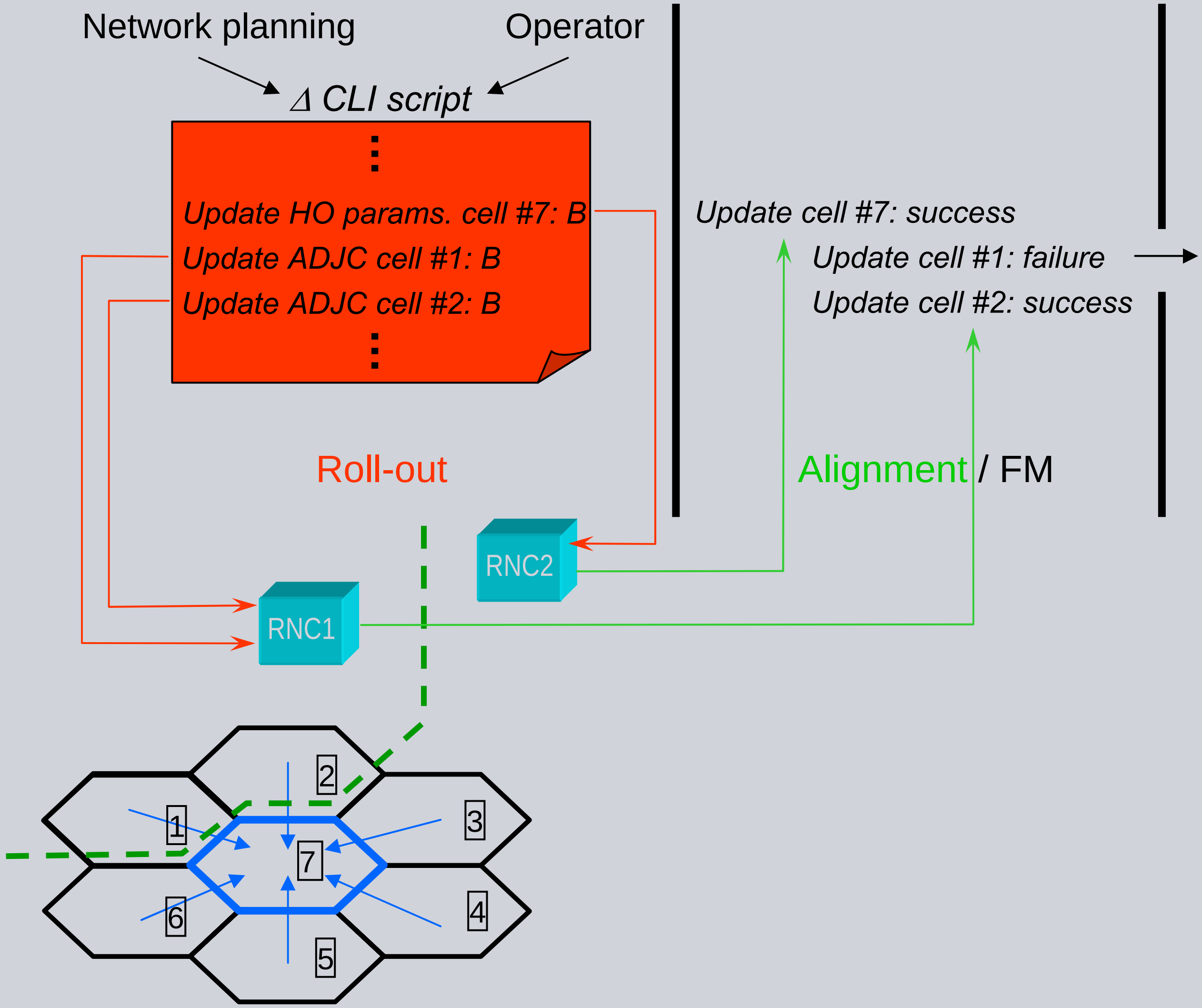

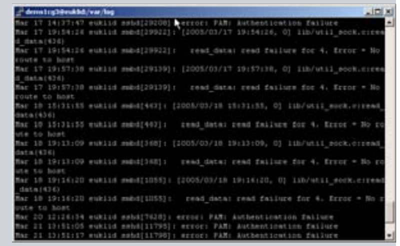

Low-level workflow:

- Verification
- Correlation of individual results
- Correction of cell #1 problem
  OR
  New script for „rollback“

Update HO params. cell #7: A
Update ADJC cell #2: A

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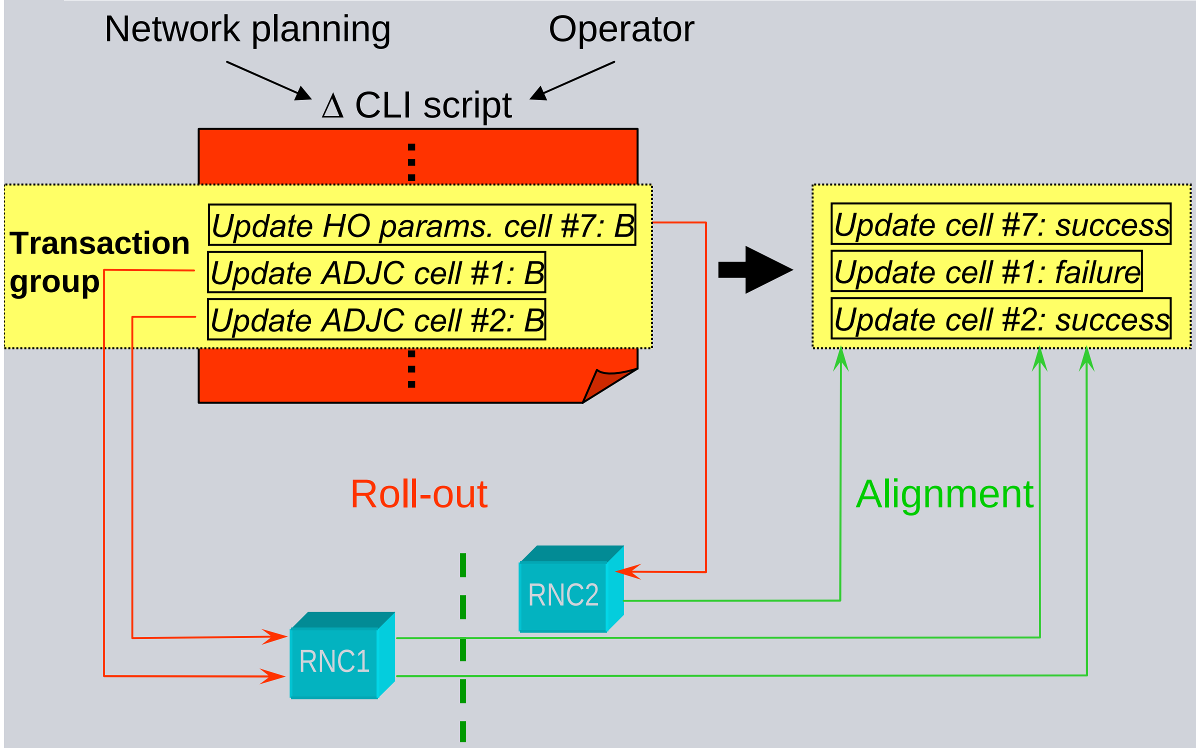
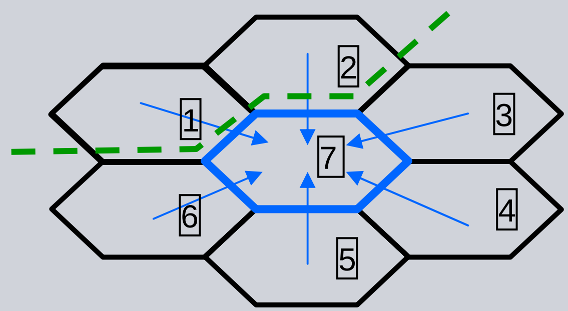
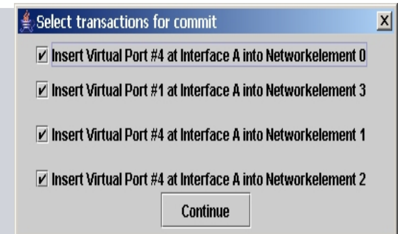
Example workflow for adjacency management: future







High-level workflow:

(Automated) operator decision between

- Temporary revocation of dependency & rescheduling of few transactions (this example)

  Update ADJC cell #1: B

- NE group-wide rollback to state A (e.g., for case *Update cell #7: failure)*

  Rollback HO params. cell #7
  Rollback ADJC cell #1
  Rollback ADJC cell #2

Scope of configuration change	*Hierarchy level*
Network	Network Transaction
NE group	Transaction Group
Single NE	Transaction
Single operation on NE	Command

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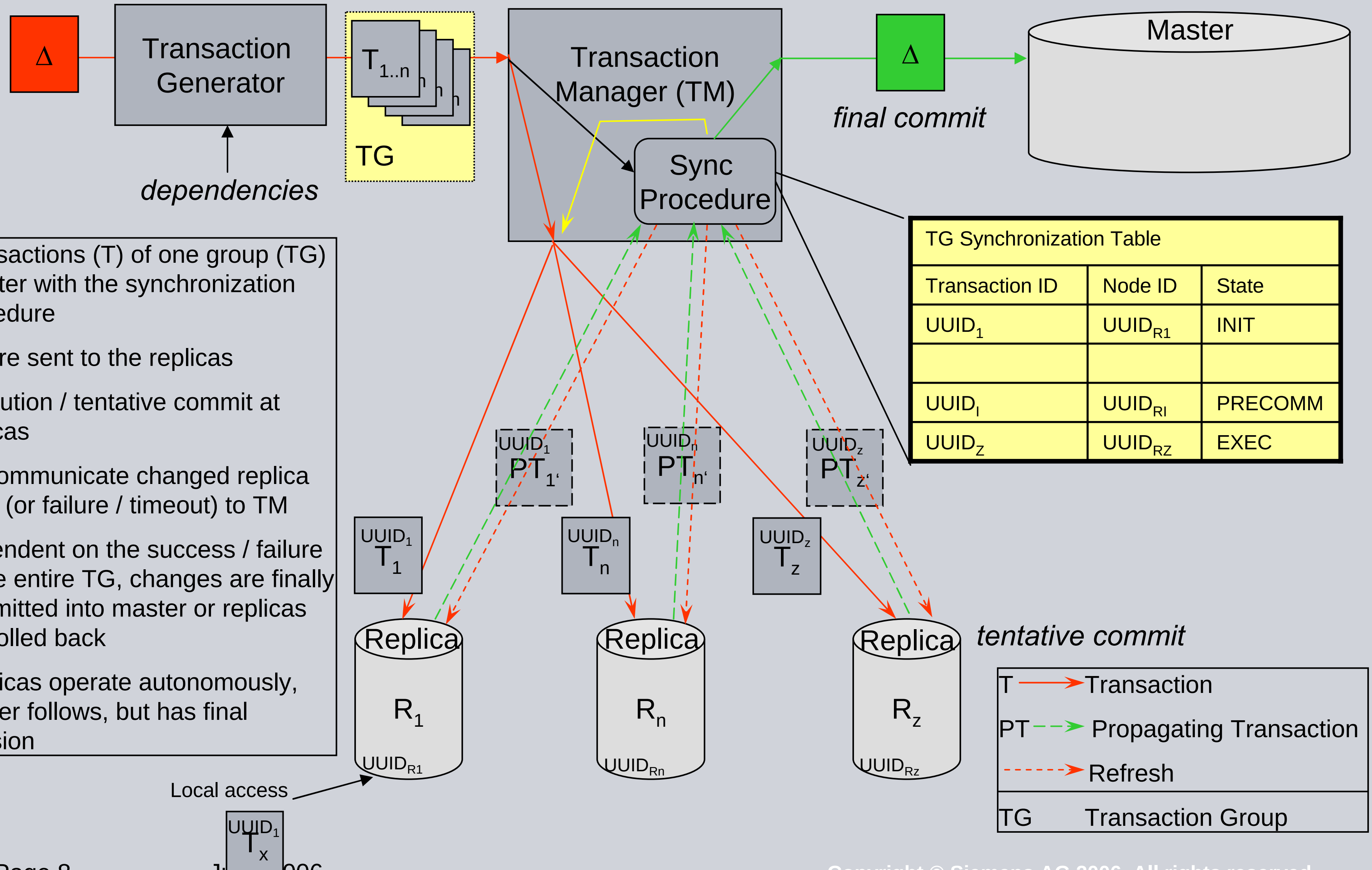
Generic master-replica data management model



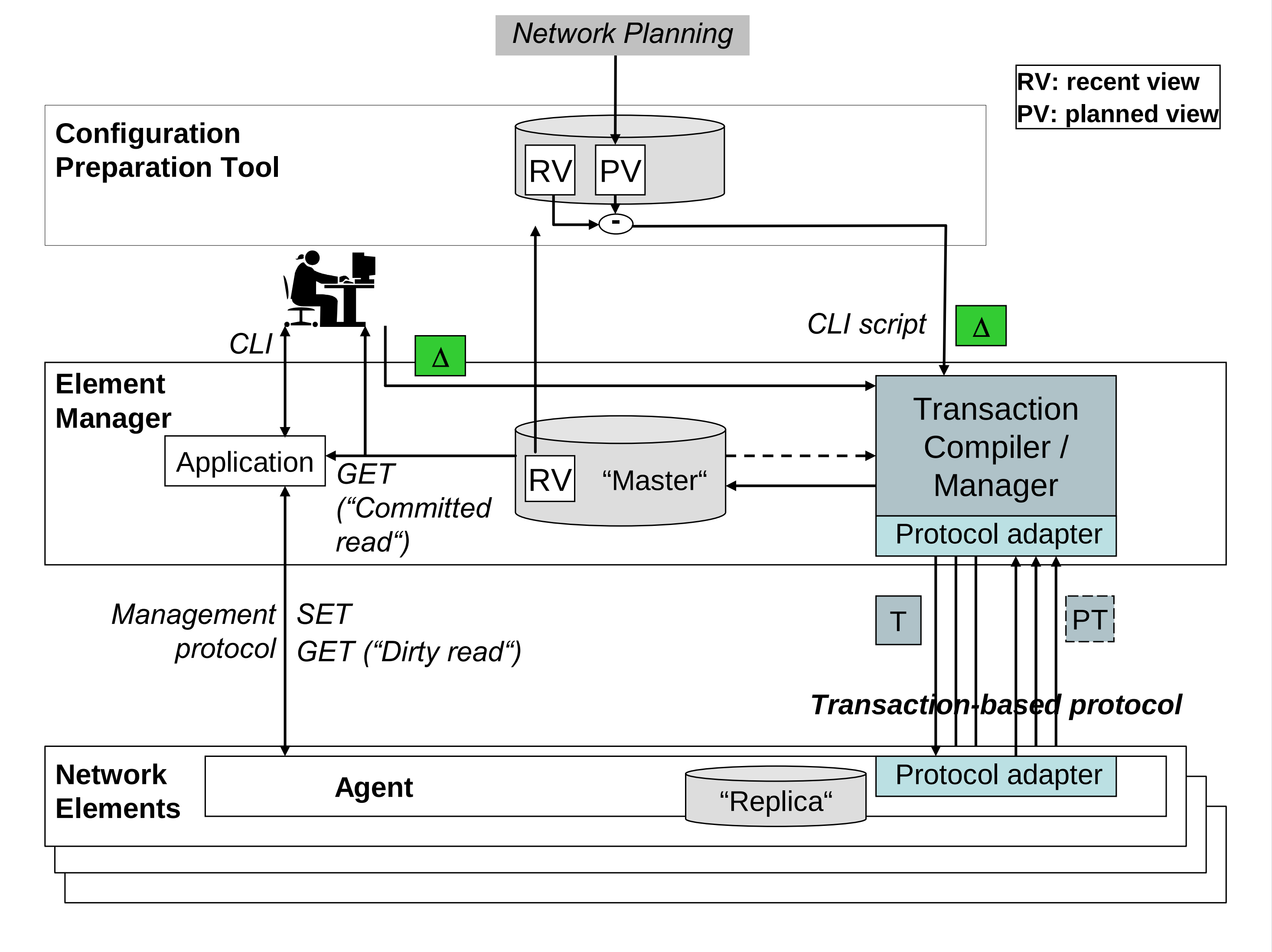
TG Synchronization Table

Transaction ID	Node ID	State
$UUID_1$	$UUID_{R1}$	INIT
$UUID_I$	$UUID_{RI}$	PRECOMM
$UUID_Z$	$UUID_{RZ}$	EXEC

- Transactions (T) of one group (TG) register with the synchronization procedure
- T's are sent to the replicas
- Execution / tentative commit at replicas
- PT communicate changed replica state (or failure / timeout) to TM
- Dependent on the success / failure of the entire TG, changes are finally committed into master or replicas are rolled back

→ Replicas operate autonomously, master follows, but has final decision

Integration into the element management architecture



Policy Examples for Automated Rescheduling / Rollback

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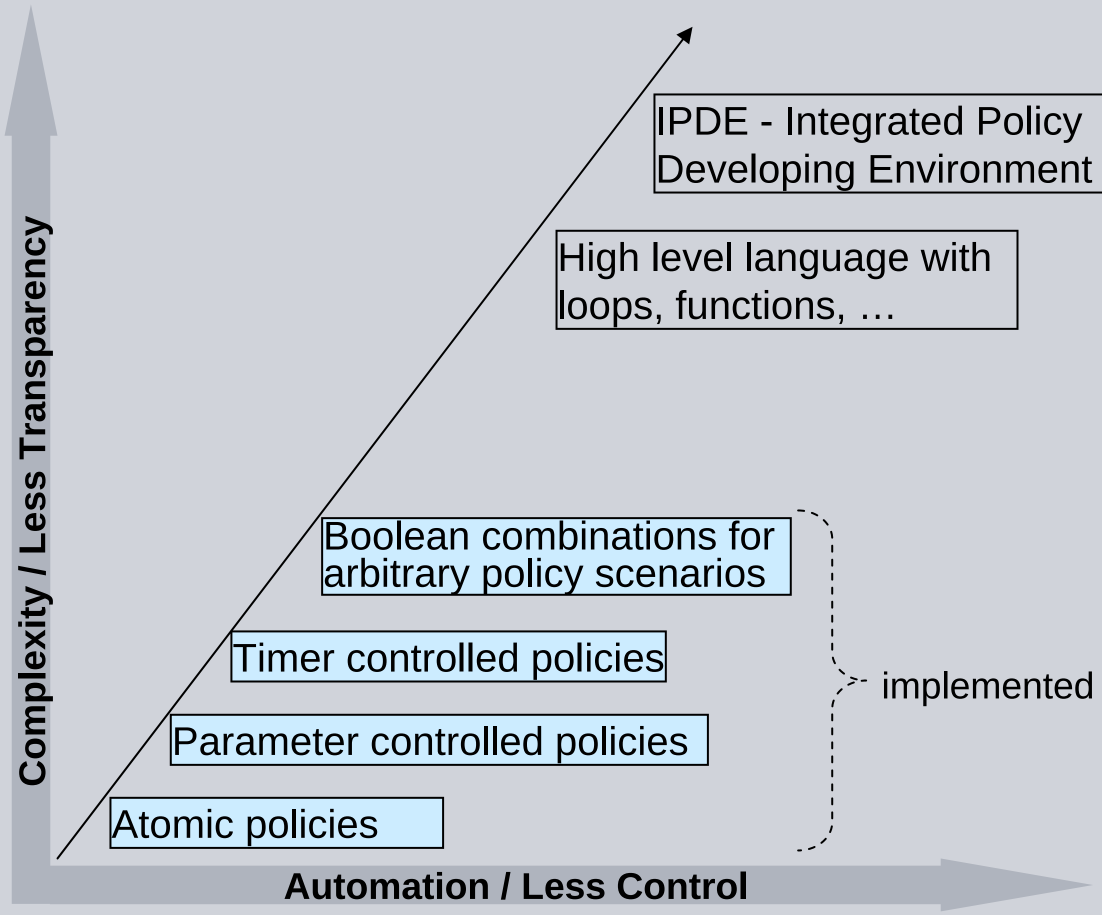
Policy properties:

- hierarchically organized (atomic and derived polices)
- tool-box supporting remote editing
- optimizing and learning process
- smooth migration and development possible
- high-level language necessary (subject for standardization?)
- monitoring, tracing, evaluation (appropriate GUI requested)
- complexity vs. automation
- transparency vs. control
- potential for OPEX reduction

→ policy environments for automated rescheduling and rollback are feasible already now, with IPDE as long-term goal



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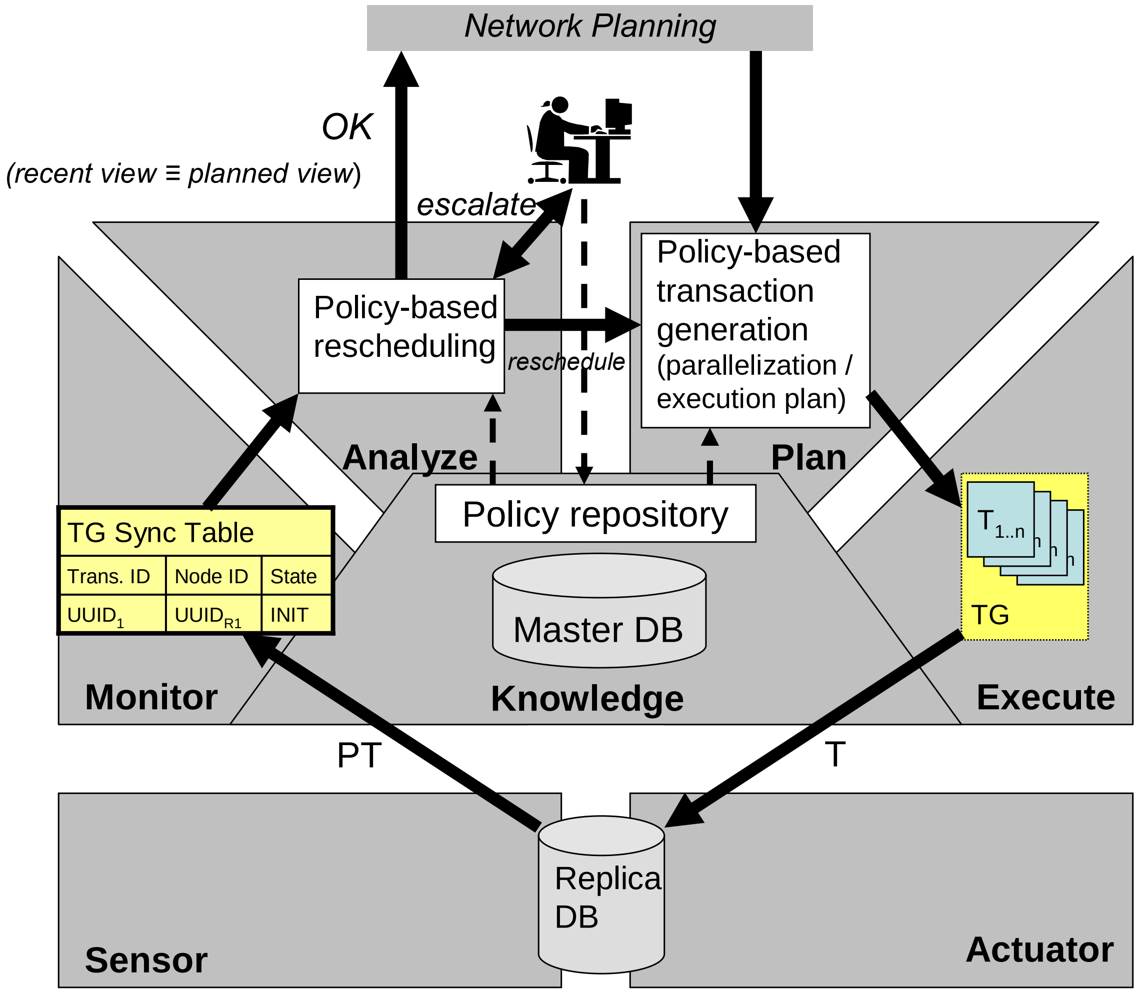
Proposed solution: master-replica data management subsystem

Category	*Requirements to a full solution*	*Solution properties*
Roll-out phase	Assurance of inter-NE consistency	Transaction compiler: generates transactions from delta between recent and planned view (input: dependencies, execution plan) Transaction manager: rolls-out and monitors transactions
	Transactions at EMS level	
	Parallelization	
	Automation	
	Transaction-oriented protocol	Transaction-oriented protocol between master / replica (=NE), transactions at replica
Alignment phase	Delta alignment	Middleware (Transaction manager): controls access to master by replicas Protocol: delta updates as transactions
Non-functional properties	Bandwidth efficiency	Protocol: delta configuration changes
	Robustness, “online” assurance of consistency	Middleware: concurrency awareness Protocol: reliable messaging, transactions
	Scalability	Protocol / Middleware: several 100 replicas tested
	Efficiency through automation	Middleware: network (not NE)-level interface

Summary


Network Planning
OK
(recent view ≡ planned view)
escalate
Policy-based rescheduling
reschedule
Policy-based transaction generation (parallelization / execution plan)
Analyze
Plan
Policy repository
Master DB
TG Sync Table
Trans. ID
Node ID
State
UUID1
UUIDR1
INIT
T1..n
TG
Monitor
Knowledge
Execute
PT
T
Replica DB
Sensor
Actuator

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Conclusions

- Improvement of CM data consistency (NE/EMS & inter-NE), degree of automation
  - Manufacturer: reduced and simplified CM software development:
    - State-of-the-art data management technology can be applied
    - Applications do not need to consider low-level data consistency
  - Mobile Network Operator:
    - OPEX reduction (less (skilled) operational personnel needed)
    - Increasingly important with 3G RAN evolution
- Parallel operation to legacy CM protocols possible
- Partial introduction possible (transaction manager at EMS only)
- Info model upgrades can be nicely integrated into the roll-out process
- Proof-of-concept implementation has been done at Siemens Communications

- Future work: policy development process (encapsulating human operator‘s knowledge) based on operational experience