Blockchain-based Architectures for Food Supply Chain Management

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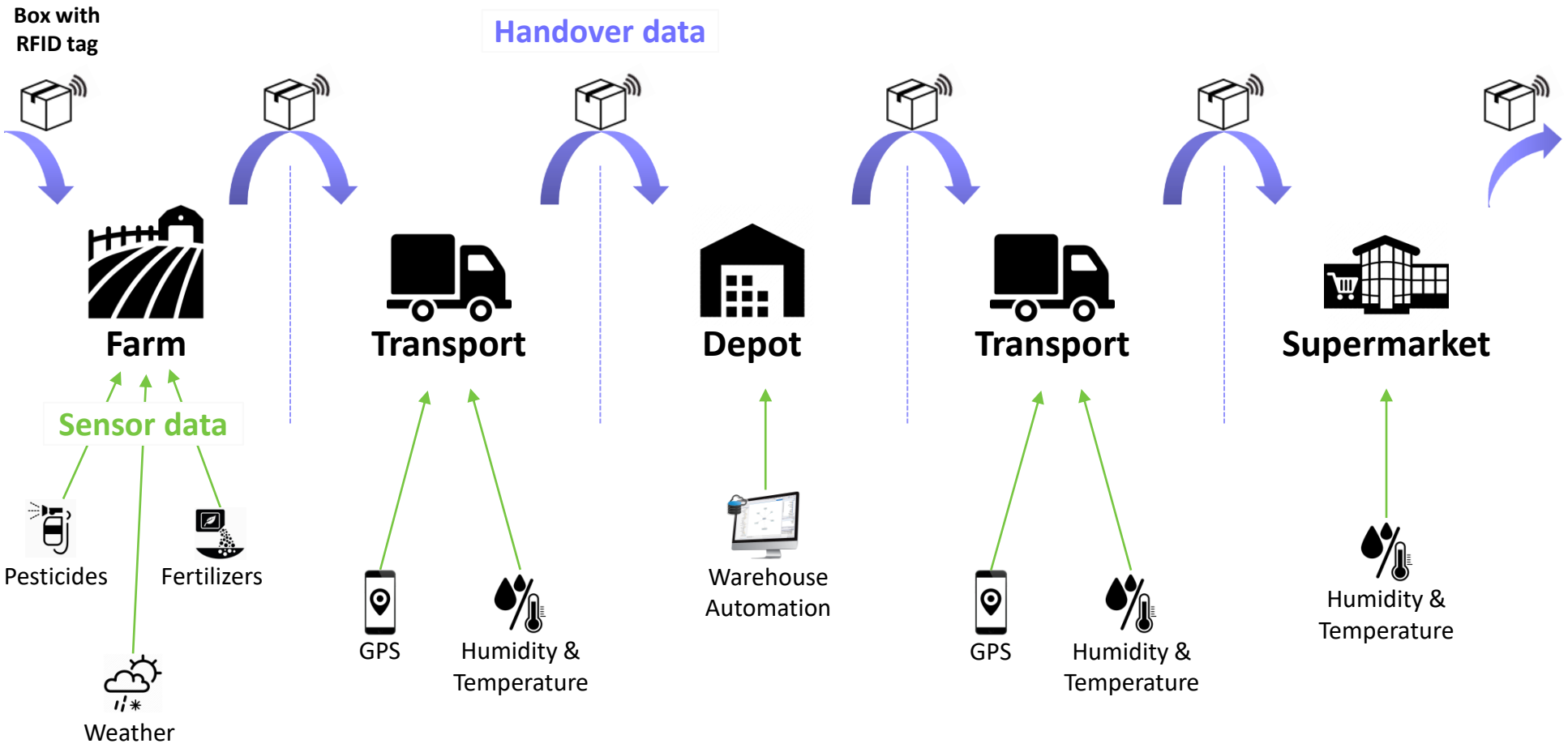
Food Supply Chain



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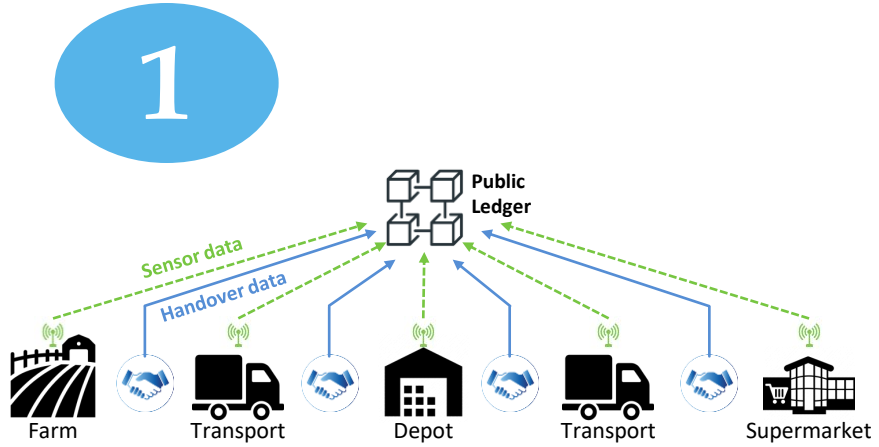
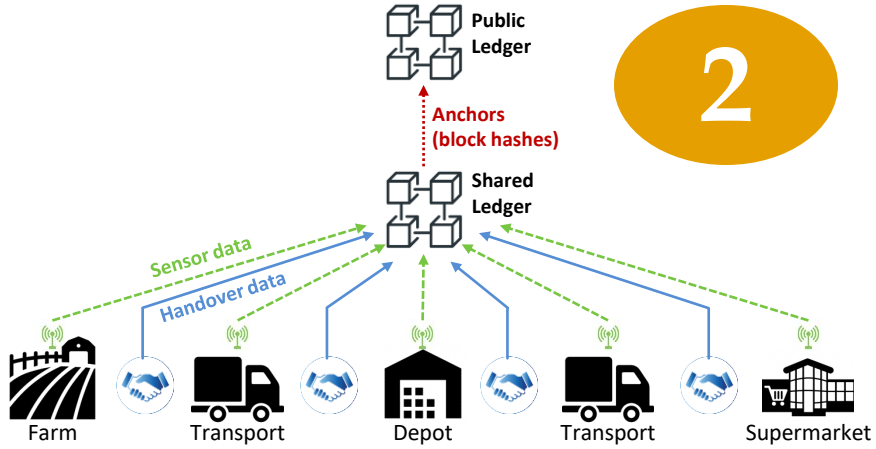
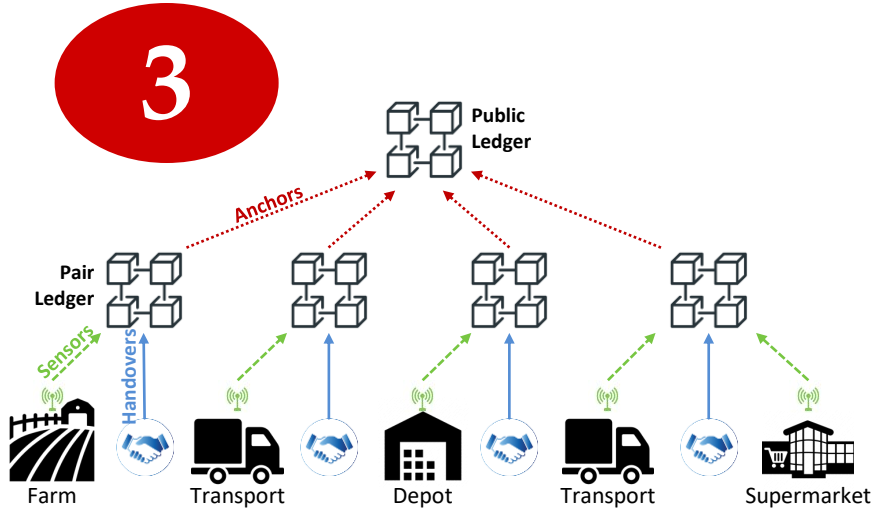
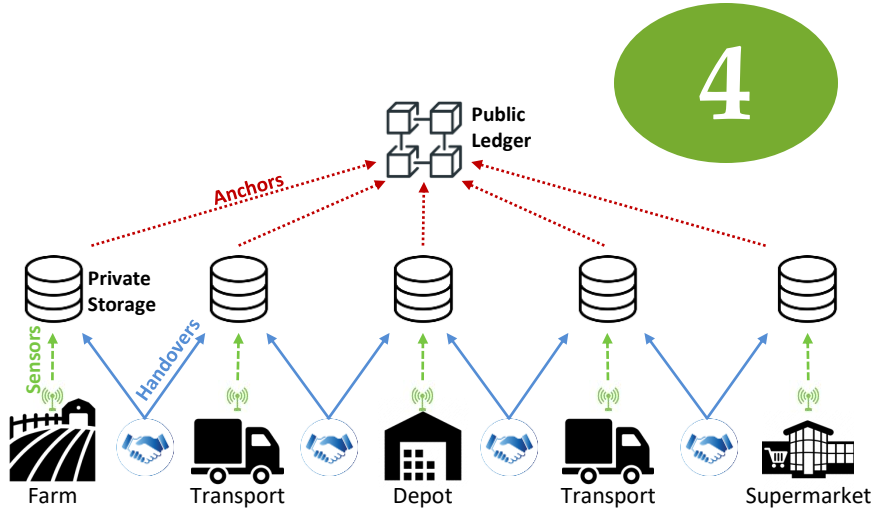
Scenarios Considered









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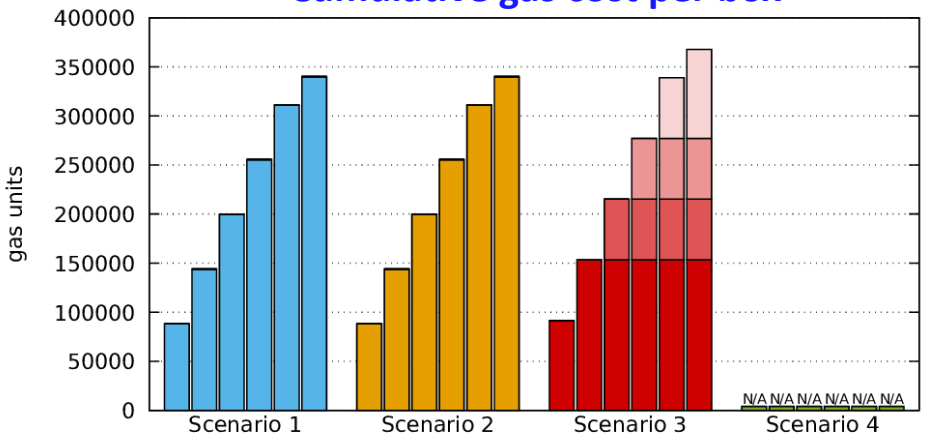
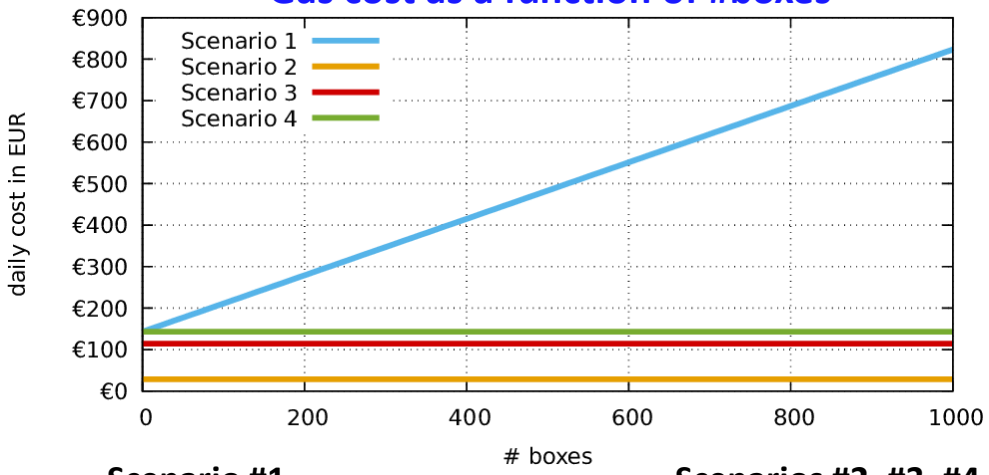
Cost Analysis

Cumulative gas cost per box



Gas cost as a function of #boxes



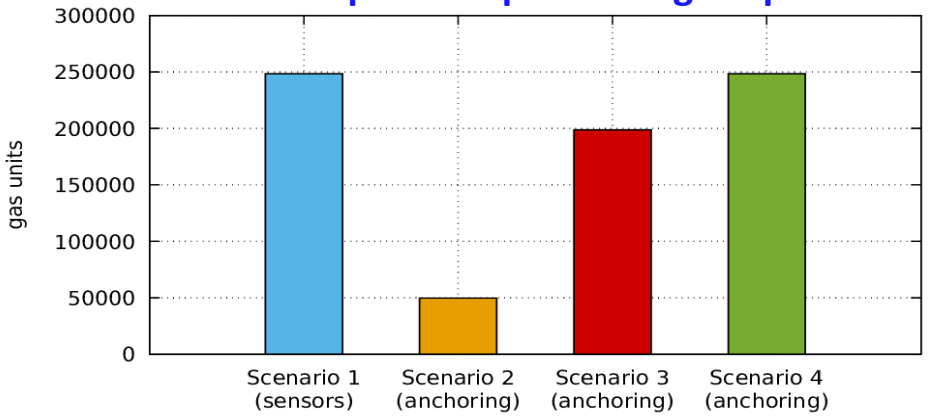
Scenario #1

- Basic periodic costs (~€143)
- + Box processing cost (linear)

Scenarios #2, #3, #4

- Flat cost: Basic periodic operations

Gas cost of periodic public ledger operations



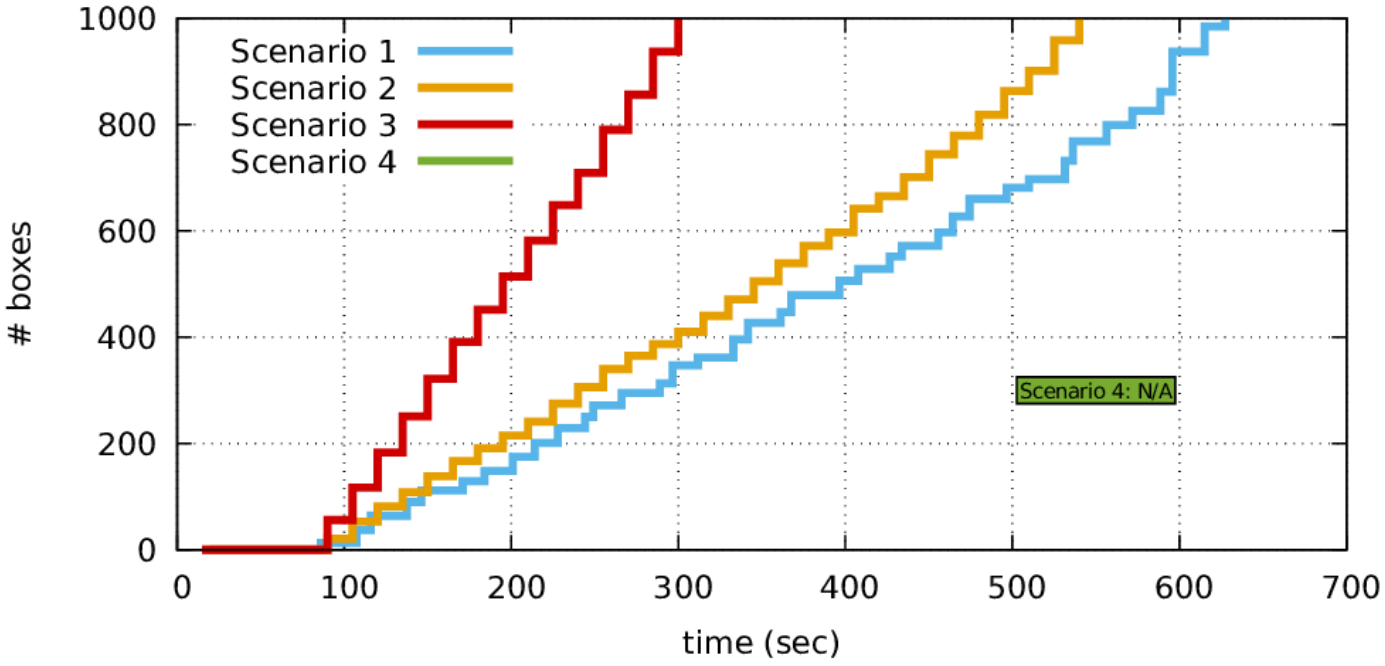
Full day's operation (6000 boxes)

	Cost for 6000 boxes			Full-day periodic costs			Total
	Gas	Ether	EUR	Gas	Ether	EUR	EUR
Scenario 1	2040M	20.4	€4080	71.5M	0.715	€143	**€4223**
Scenario 2	0	0	€0	14.3M	0.143	€28	**€28**
Scenario 3	0	0	€0	57.2M	0.572	€114	**€114**
Scenario 4	0	0	€0	71.5M	0.715	€143	**€143**

(Assuming *€200 per ETH* and *10^{-8} ETH per gas unit*)

Throughput & Time Scalability

- Experiment
  - Submit 1000 boxes at once, and observe each scenario's processing speed
- Observations
  - 1000 boxes take:
    - Sc #1 → ~620sec
    - Sc #2 → ~540sec
    - Sc #3 → ~300sec
    - Sc #4 → <unlimited>
  - Linear relation between #boxes and time
  - Throughputs
    - Sc #1 → 1.89 box/sec
    - Sc #2 → 2.22 box/sec
    - Sc #3 → 4.76 box/sec
    - throughput(Sc. #3) = 2.2 * throughput(Sc. #2)



Conclusions

- Using a public ledger only (Scenario #1)
  - is too expensive
    - daily: more than €4000 vs. less than €150
  - offers the highest possible data availability
- Using a single shared ledger (Scenario #2)
  - is the least expensive (anchoring becomes as low as it gets)
  - can have severe throughput limitations, especially for FSC with lots of branches and activity
- Using multiple shared ledgers (Scenario #3)
  - appears very appealing both w.r.t. cost as well as throughput and scalability
  - offers better privacy, as not all entities are involved in all blockchains
- Using local storage (Scenario #4)
  - has virtually no ledger-imposed speed limits
  - may result in lower data availability

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Questions!

Evaluation

Evaluation Criteria

- Public Ledger operation costs
  - in terms of “gas”
- Throughput
  - Number of boxes processed per time unit
- Scalability
  - cost
  - time
- Data Availability

Implementation Settings

- Ledger
  - Ethereum
    - Ganache for local, Ropsten for public
  - Remix and Truffle framework
- Local Ethereum configuration
  - 15sec block generation time
  - 10M gas units limit per block
- Other configuration
  - Sensor logging period: 5 minutes
  - Anchoring period: 5 minutes

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Operations and Costs

Box entry	
Session ID	256 bits
Employee ID	32 bits
Time	32 bits

Handover	
Empl_1 ID	32 bits
Empl_2 ID	32 bits
Weight	32 bits
Time	32 bits

Box exit	
Employee ID	32 bits
Time	32 bits

Sensor logging	
Sensor data	256 bits

Anchoring	
Block hash	256 bits