



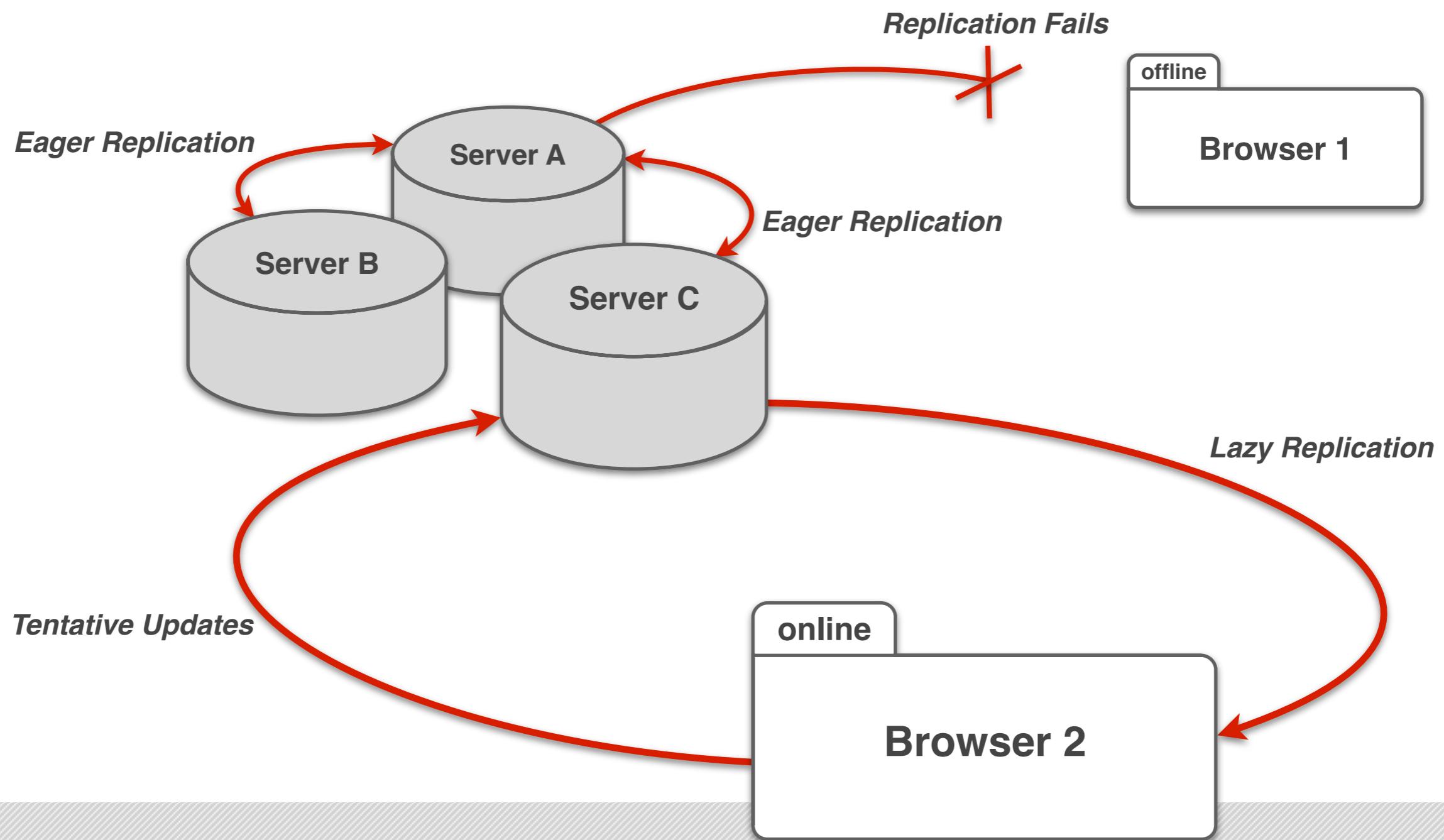
# Data Replication for Offline Web Applications

## Optimizing Synchronization, Persistence and Conflict Resolution

- › Master Thesis Samuel Esposito
- › Supervisors: Prof.dr. M. Aiello, MSc A.C. Emerencia
- › Second reader: Prof. dr. ir. P. Avgeriou

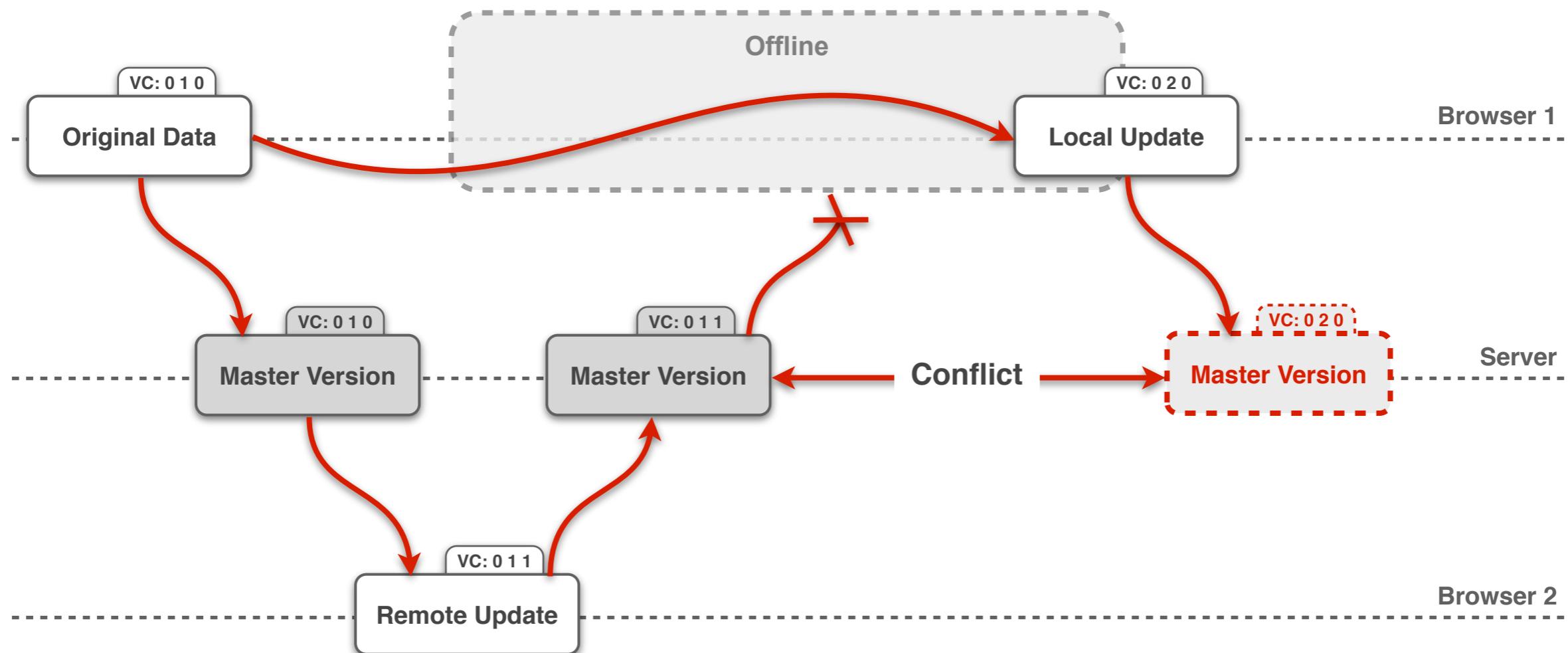


# Two-tier architecture



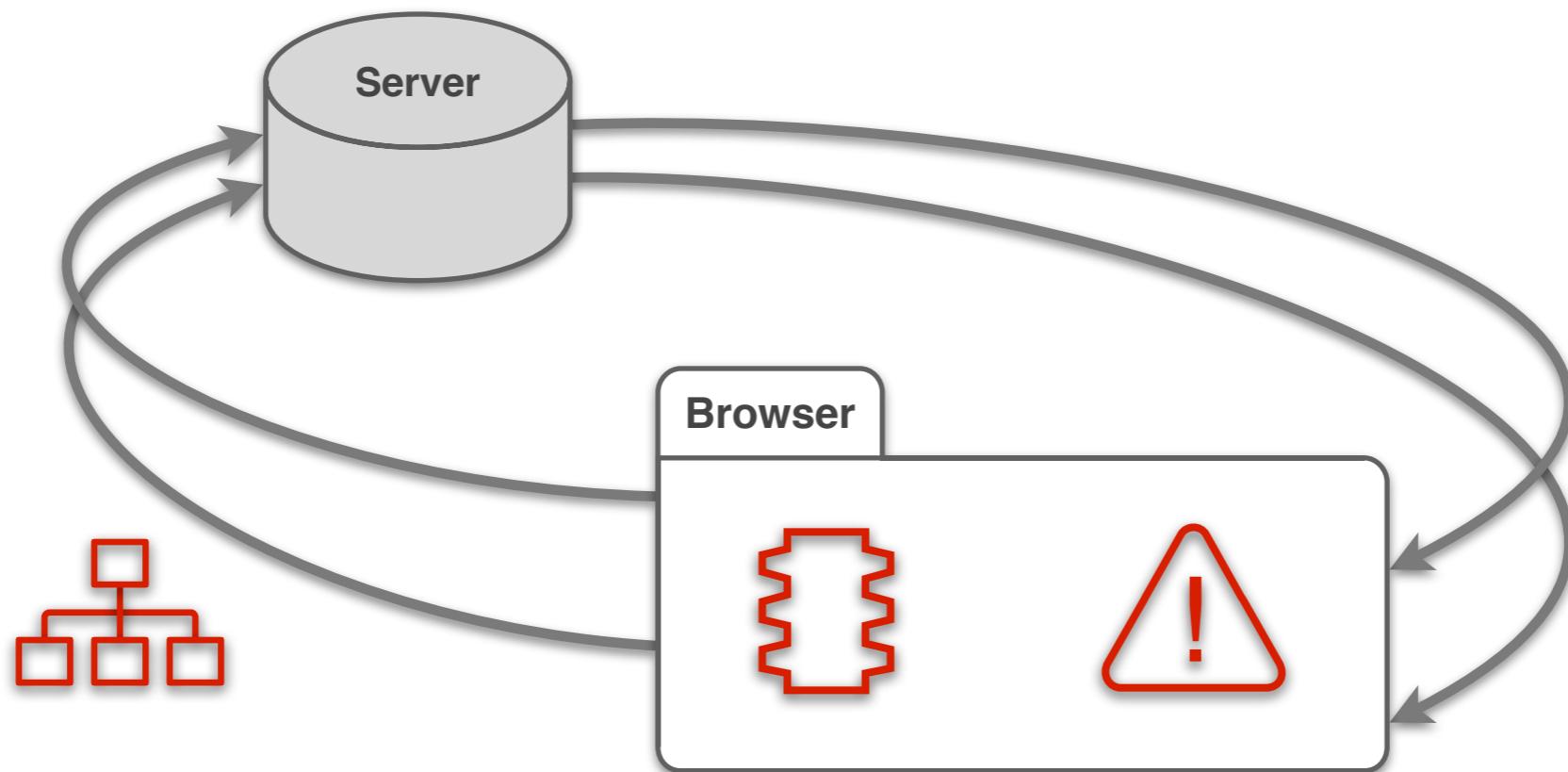


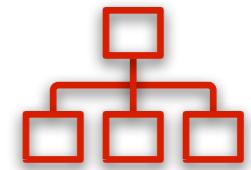
# On the origin of conflicts



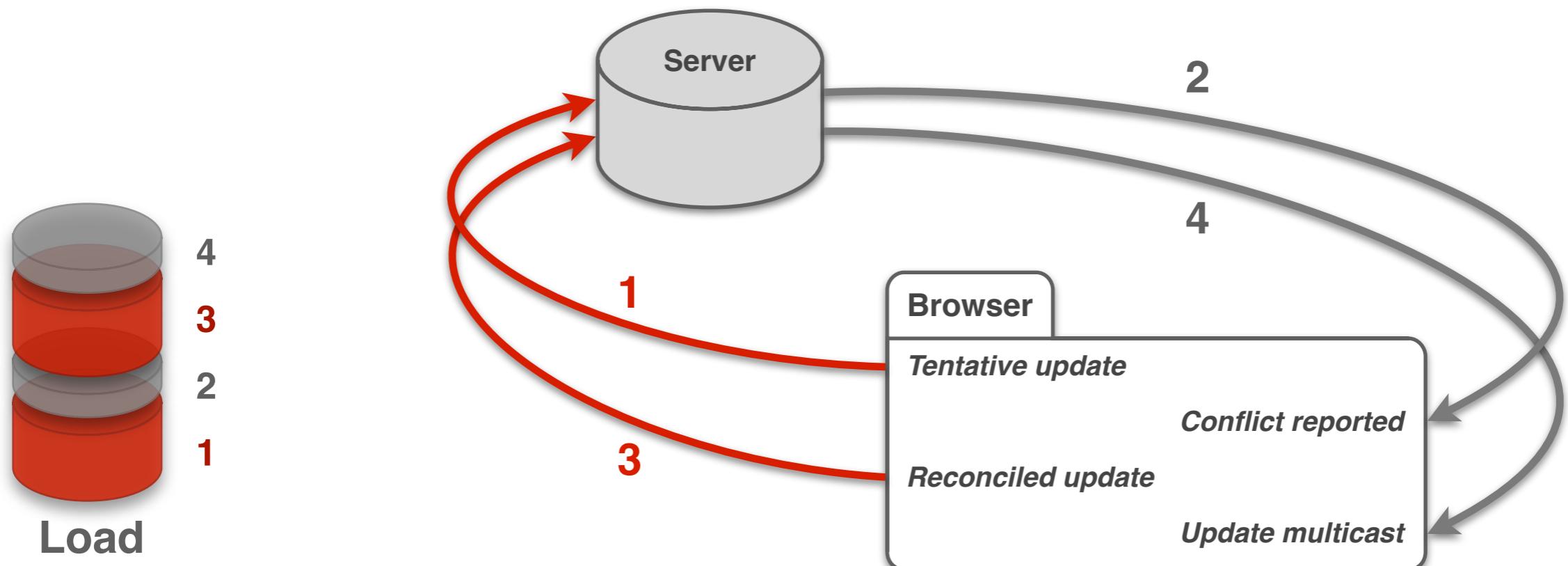


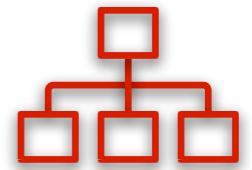
# Optimizations



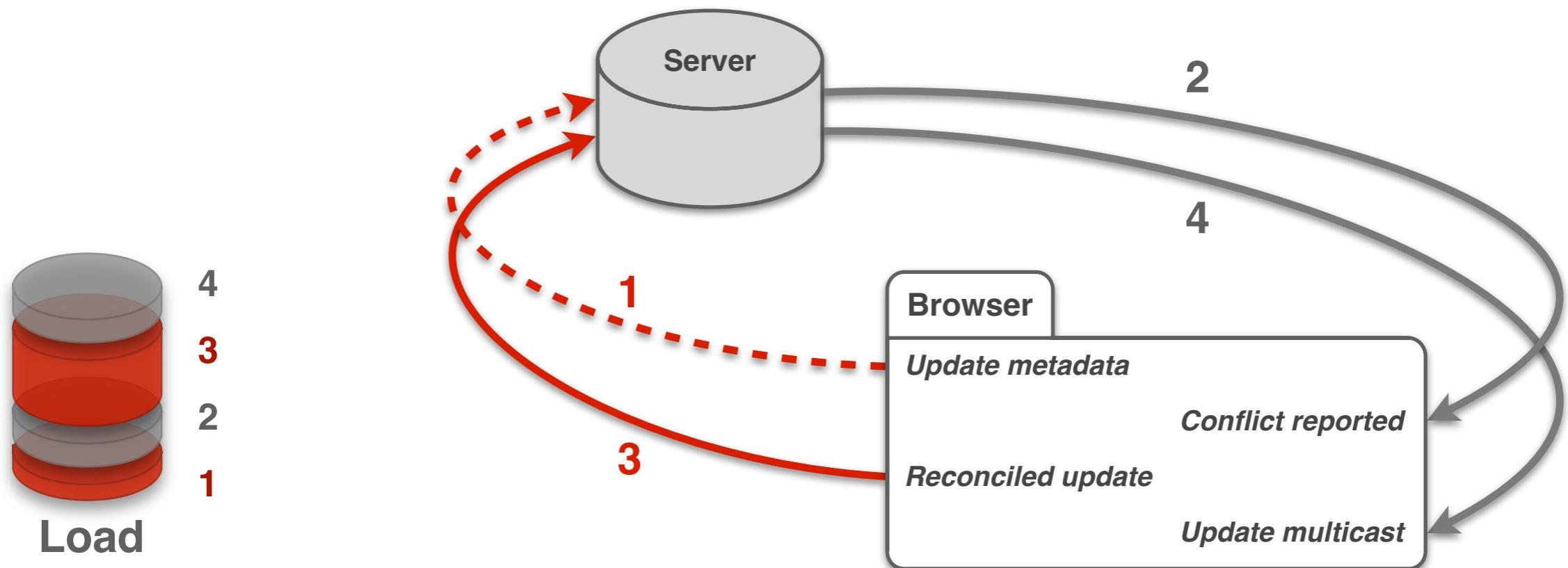


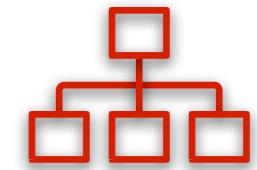
# Network load: traditional synchronization



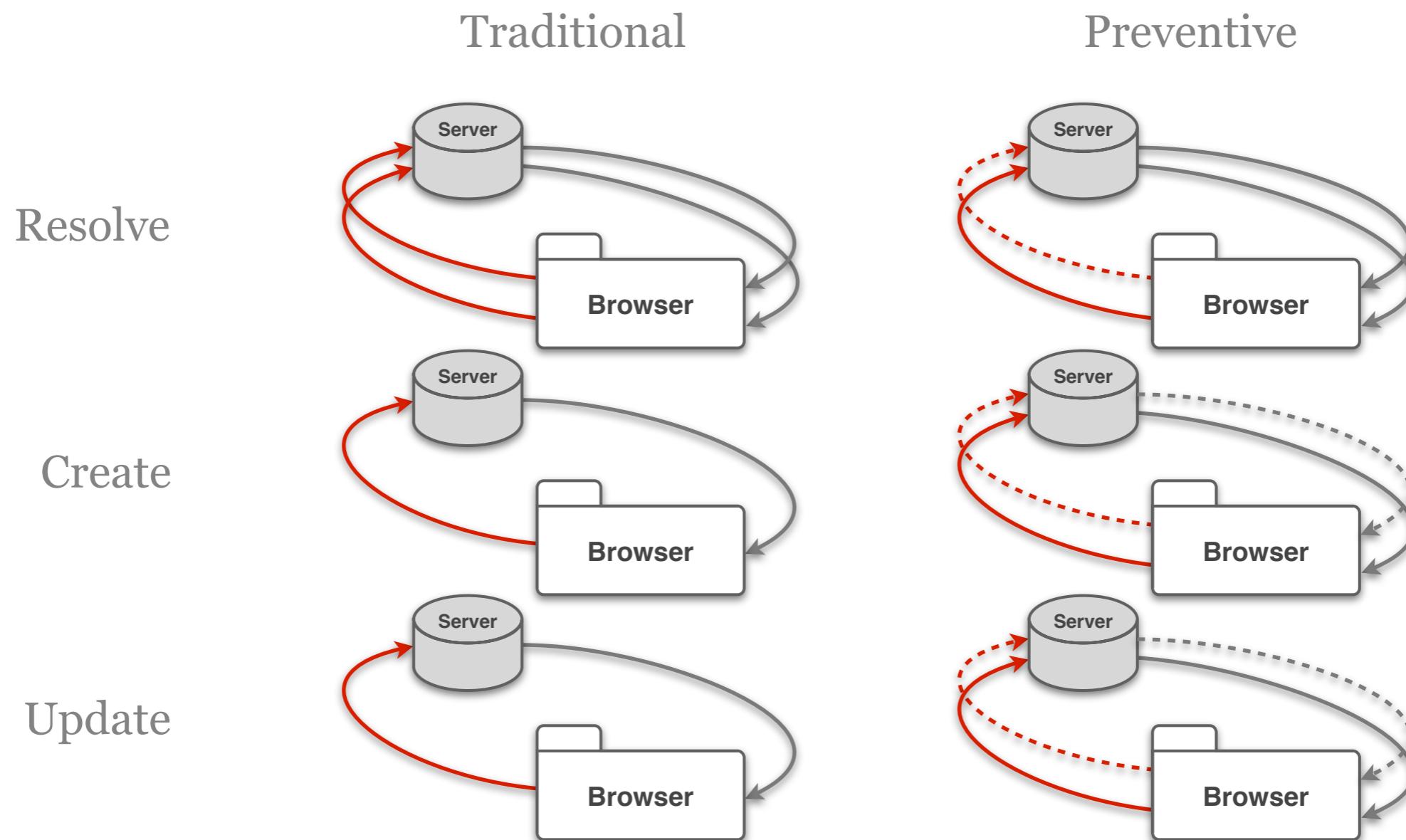


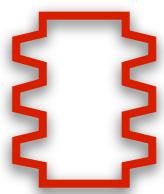
# Network load: preventive reconciliation



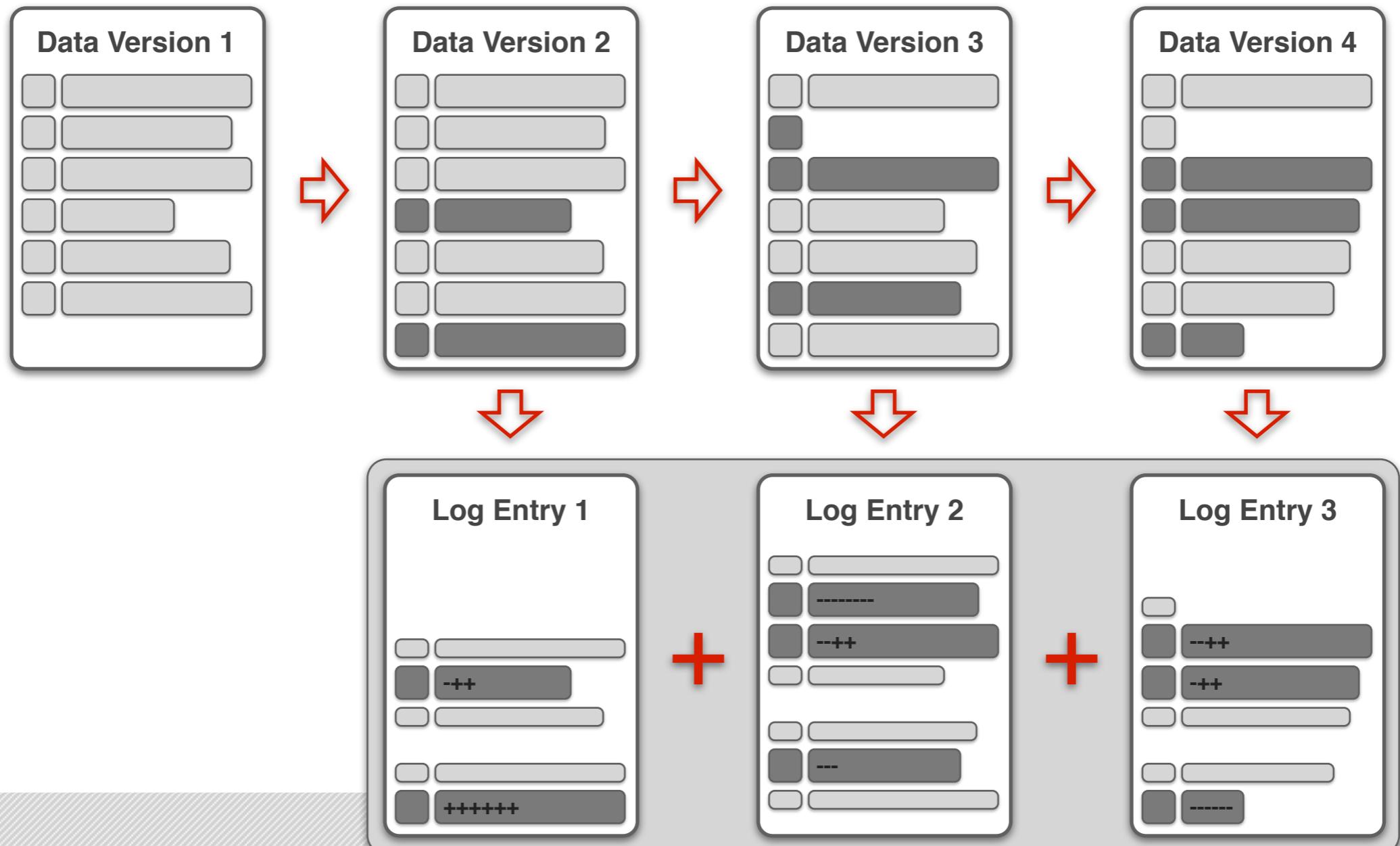


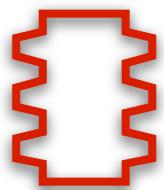
# Network load: preventive reconciliation



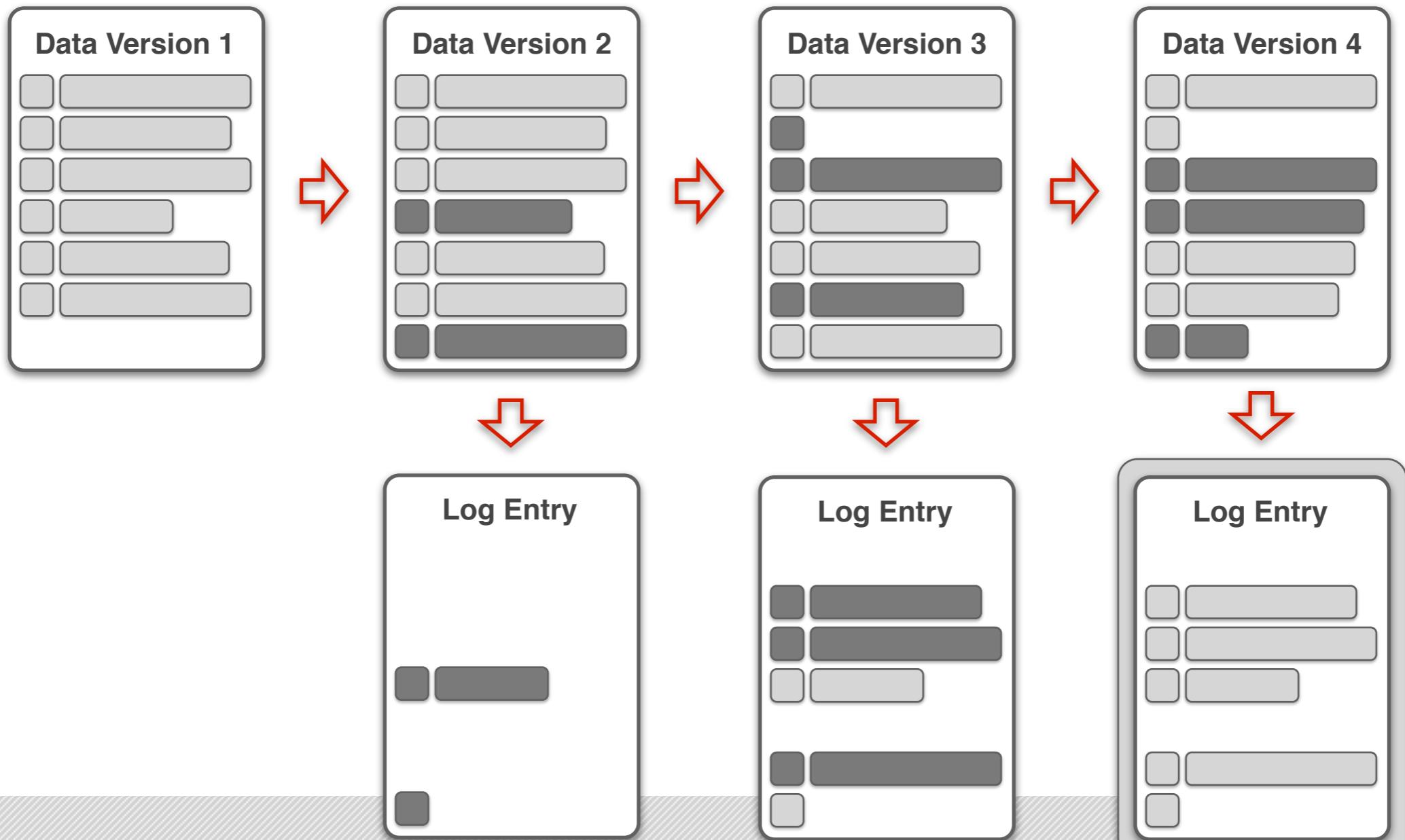


# Memory footprint: incremental browser log



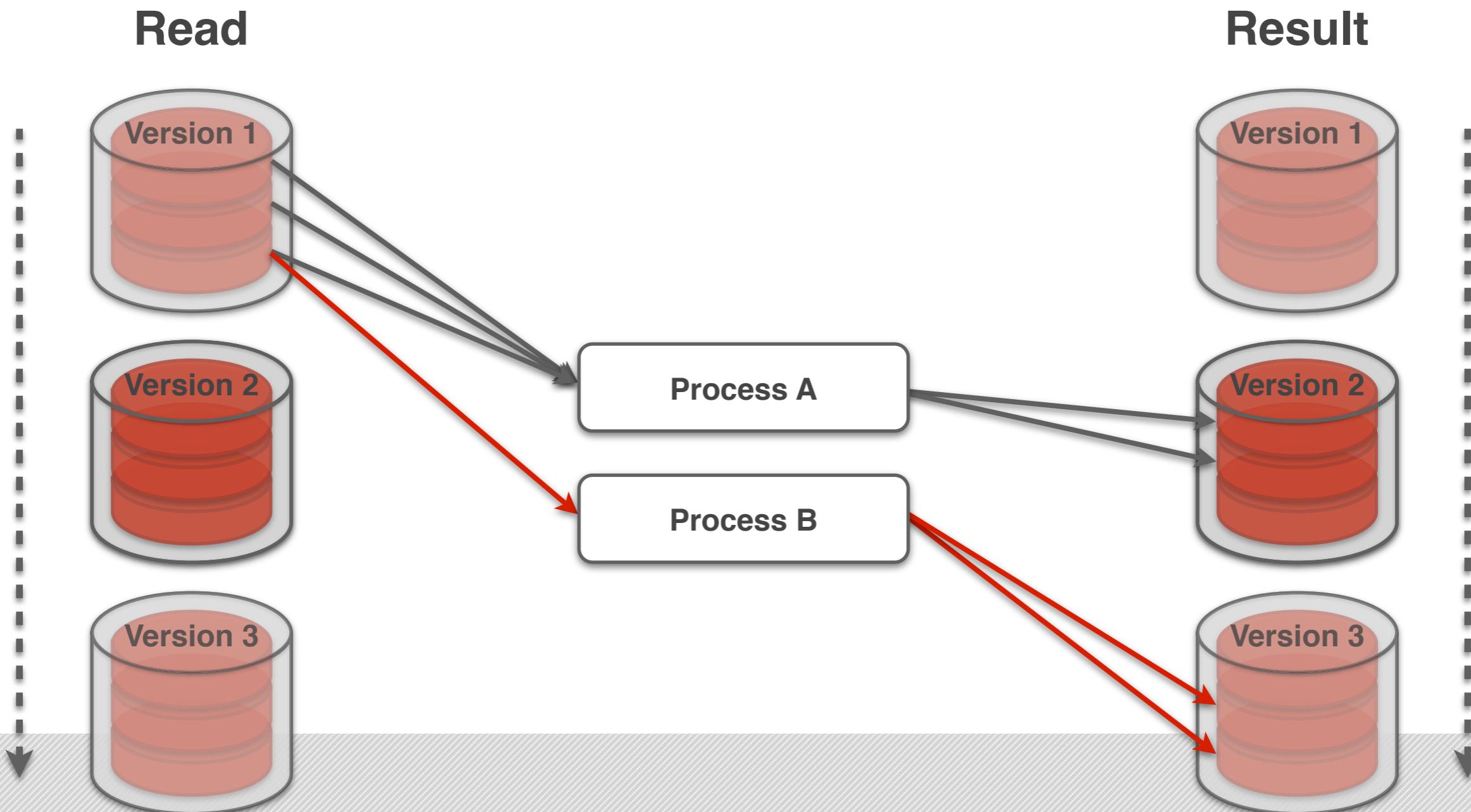


# Memory footprint: merged browser log



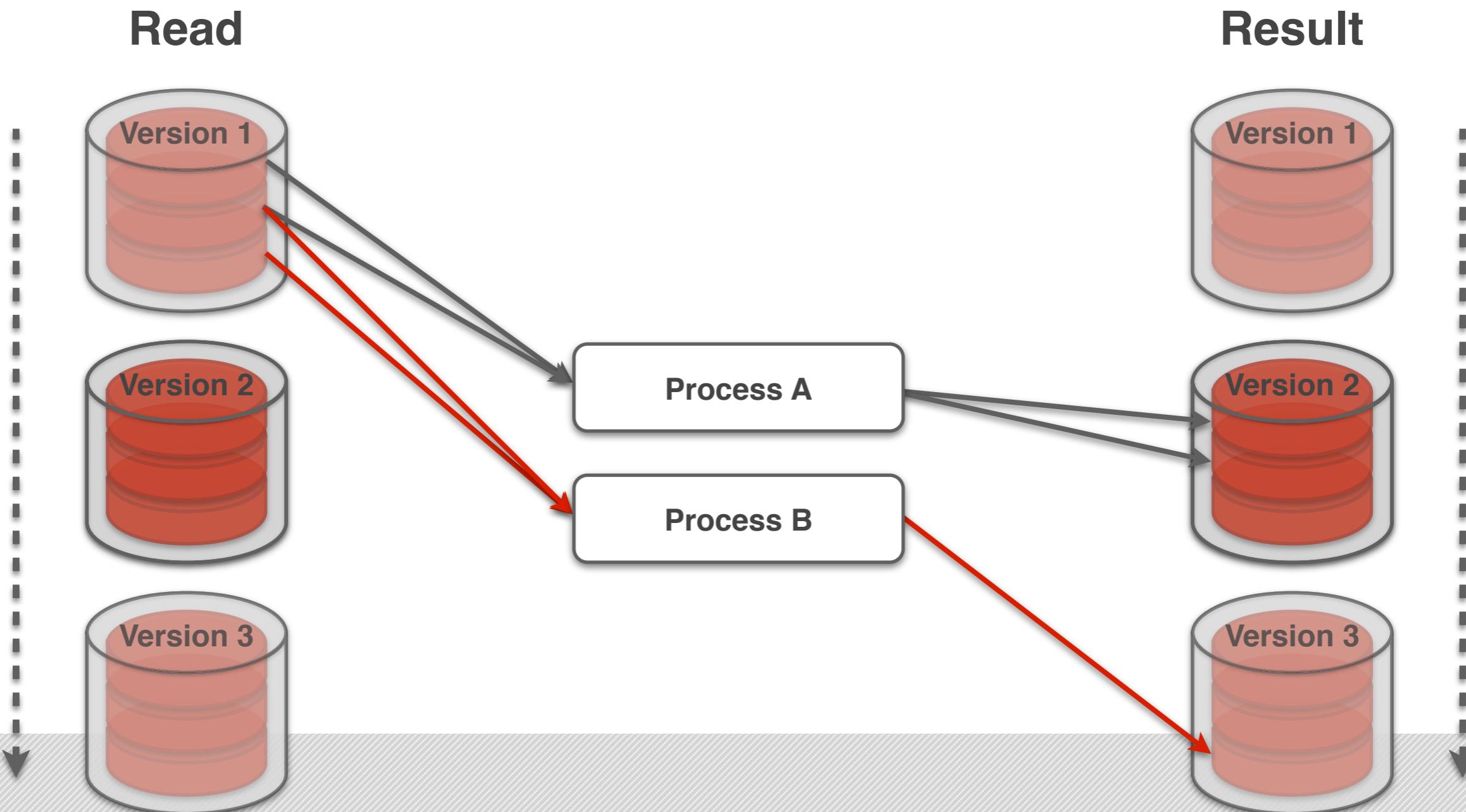


# Automated conflict resolution



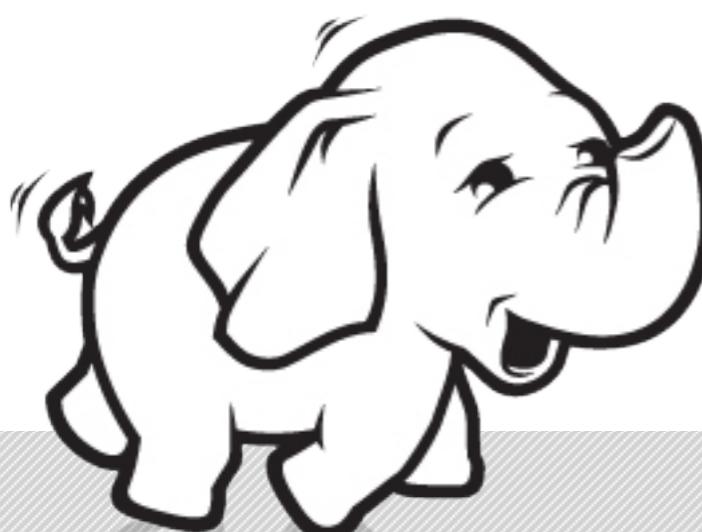
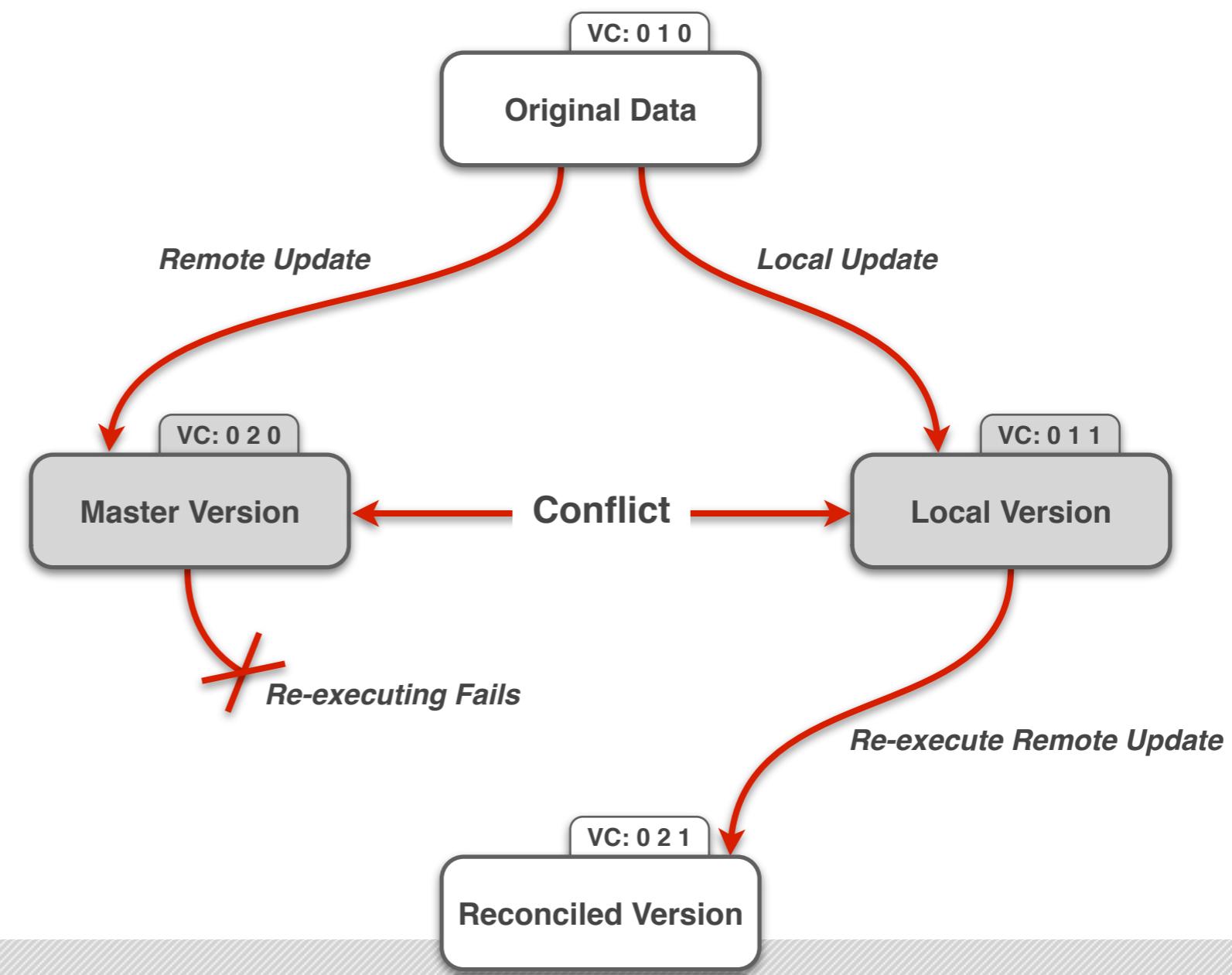


# Automated conflict resolution



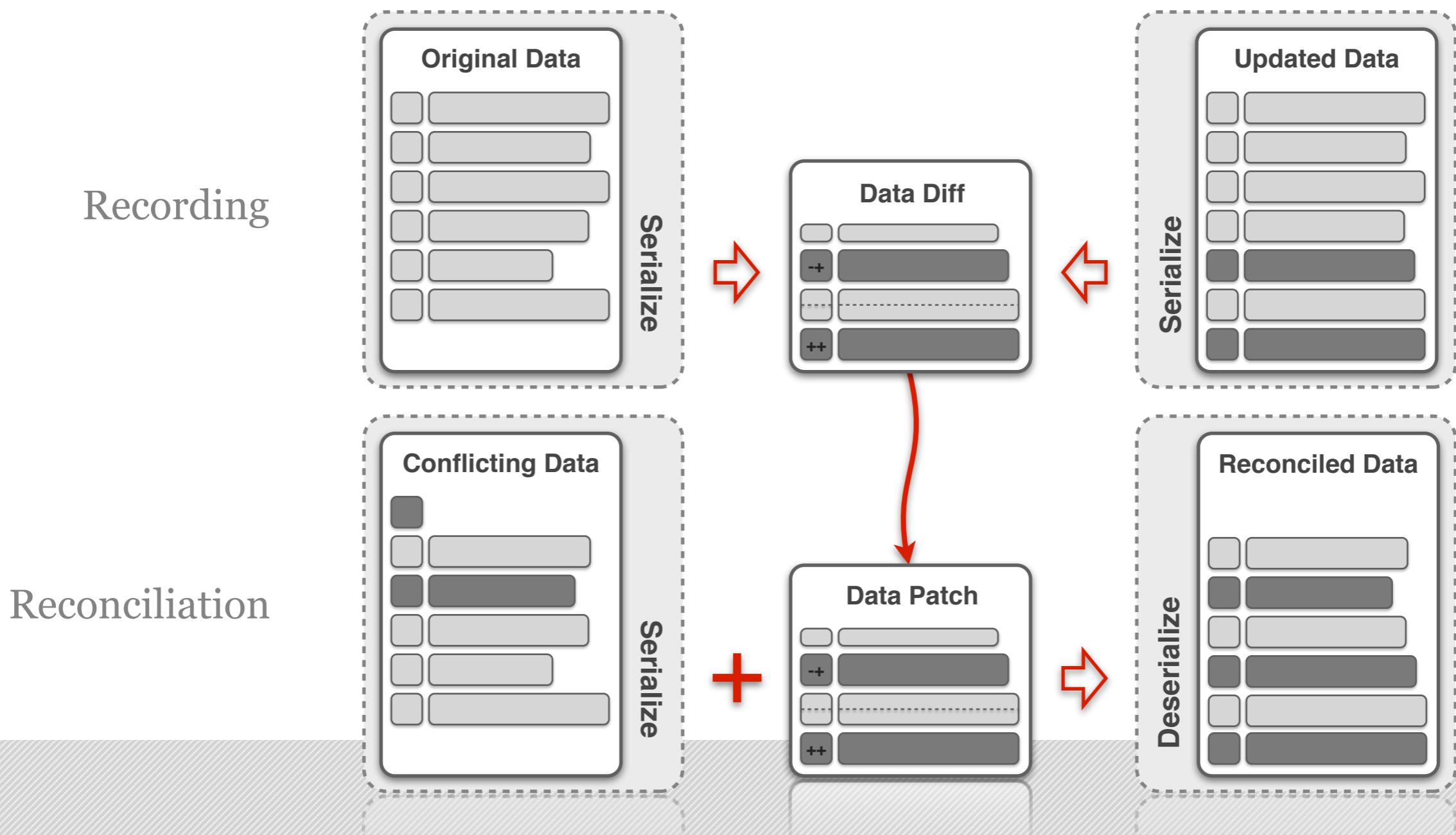


# Eager conflict resolution





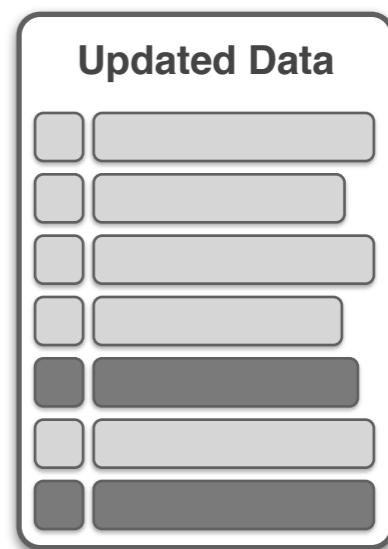
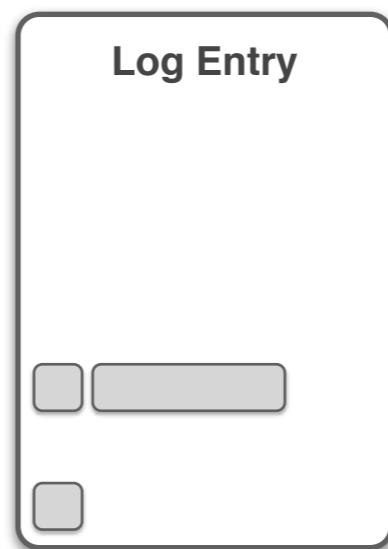
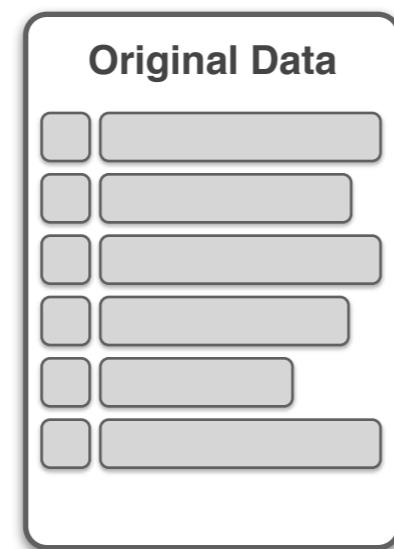
# Eager conflict resolution: serialized data





# Eager conflict resolution: attribute oriented

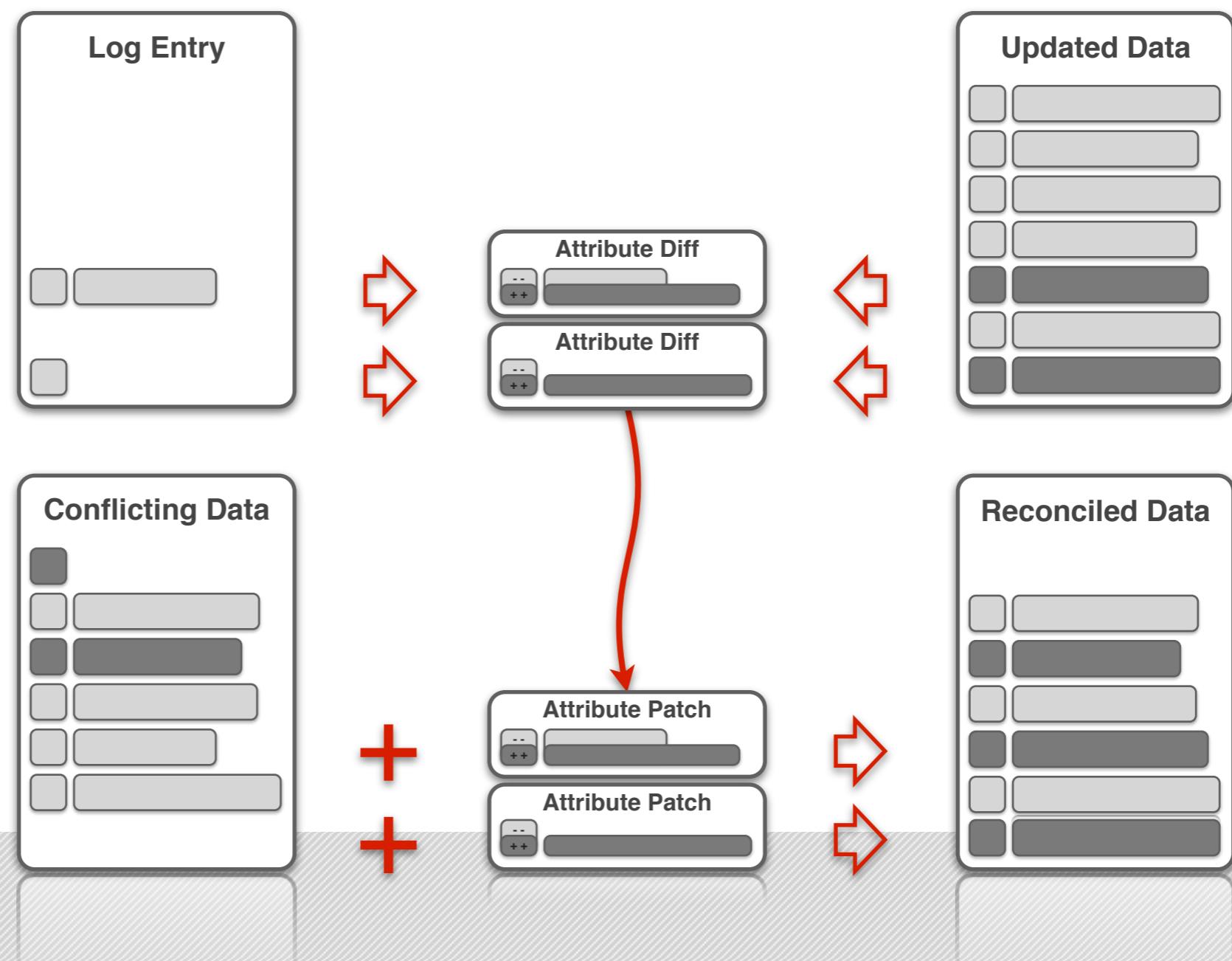
Recording





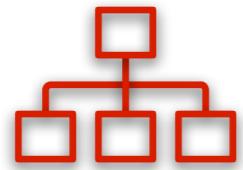
# Eager conflict resolution: attribute oriented

Reconciliation

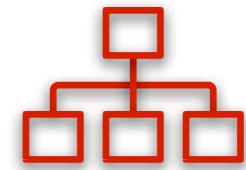




# Results



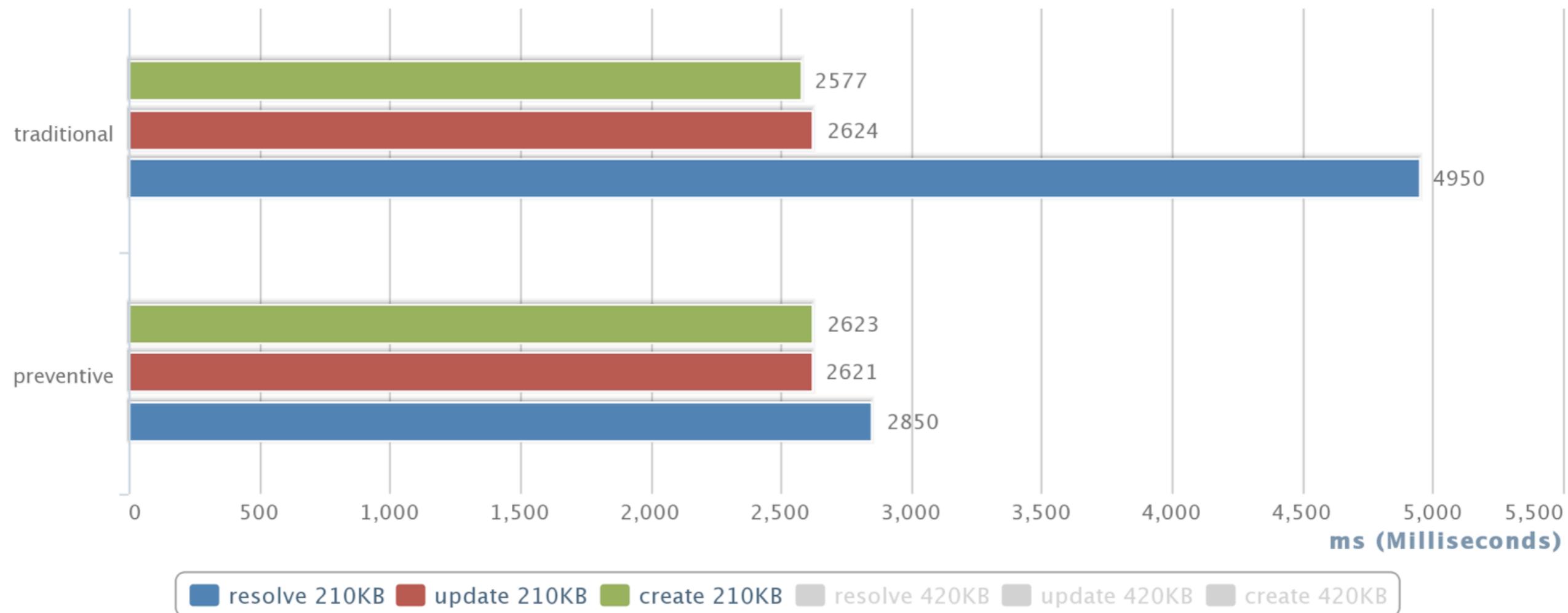
Network load

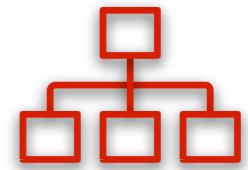


30-05-2013 |

### Traditional Synchronization vs. Preventive Reconciliation

Network load during different synchronization operations [Final Mean]

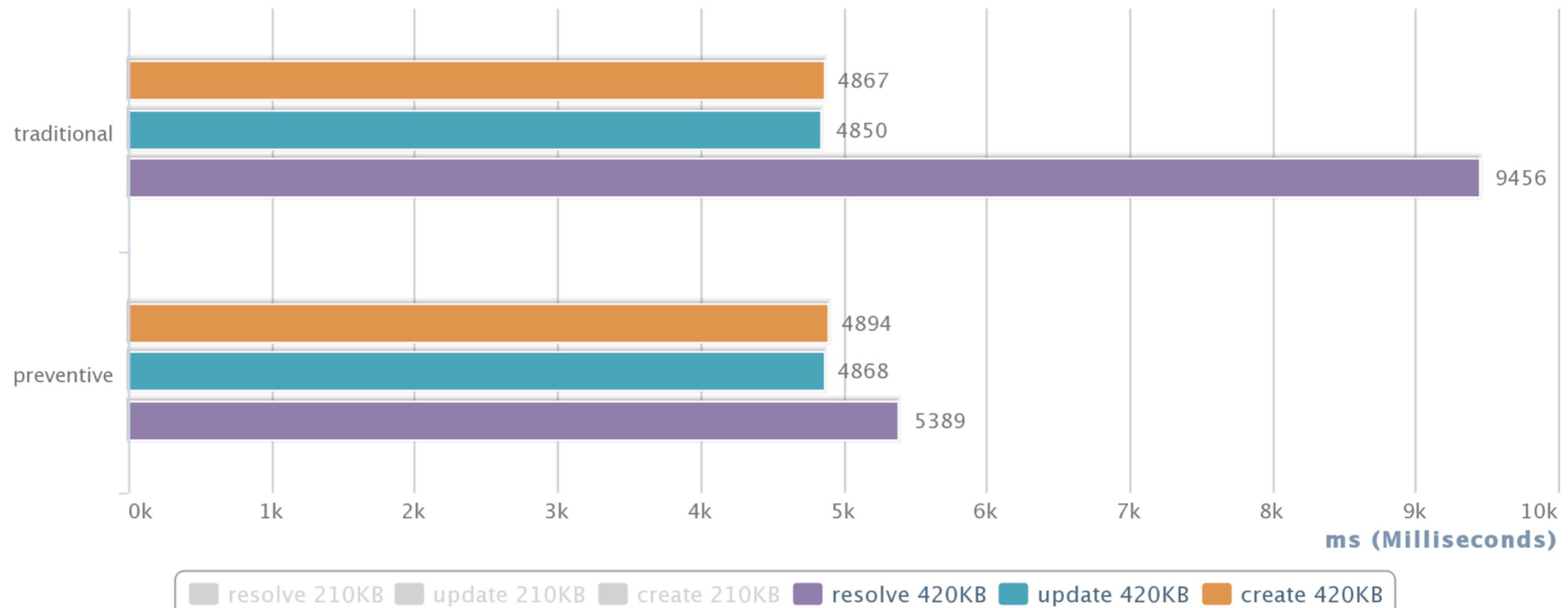




30-05-2013 |

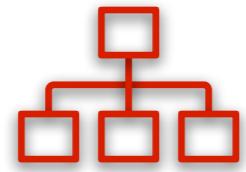
### Traditional Synchronization vs. Preventive Reconciliation

Network load during different synchronization operations [Final Mean]

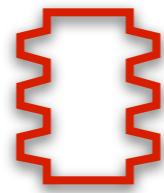




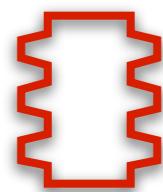
# Results



Network load

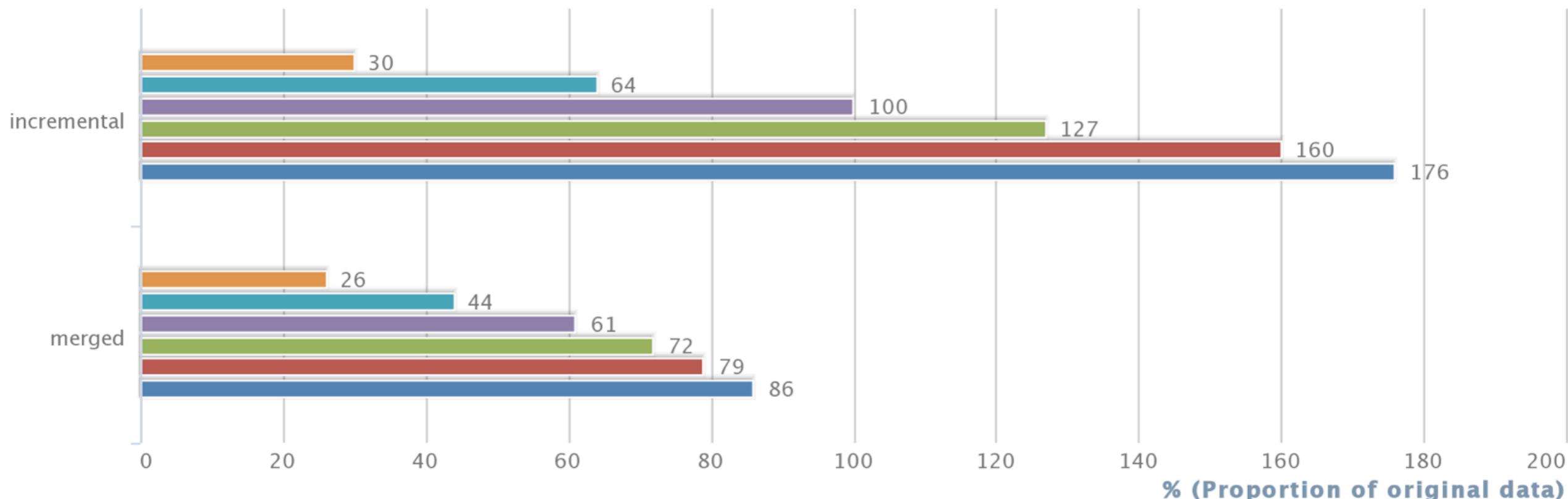


Memory footprint

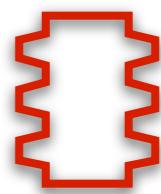


30-05-2013 |

Incremental vs. Merged Browser Log  
Memory footprint for recording local updates [Final Mean]

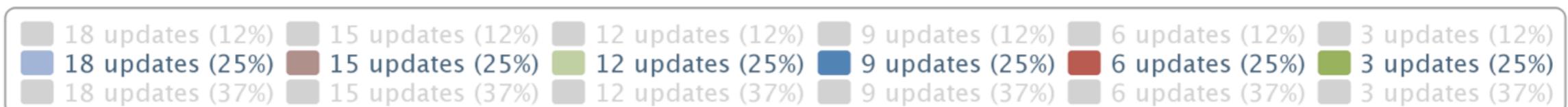
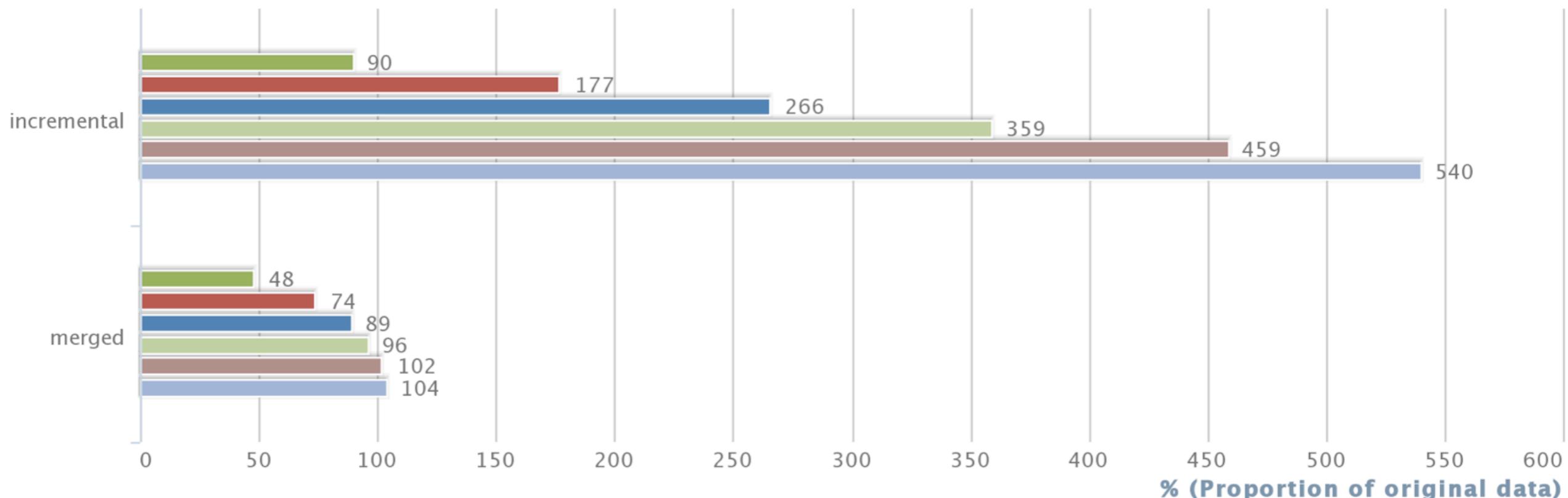


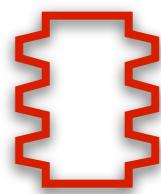
- |                  |                  |                  |                 |                 |                 |
|------------------|------------------|------------------|-----------------|-----------------|-----------------|
| 18 updates (12%) | 15 updates (12%) | 12 updates (12%) | 9 updates (12%) | 6 updates (12%) | 3 updates (12%) |
| 18 updates (25%) | 15 updates (25%) | 12 updates (25%) | 9 updates (25%) | 6 updates (25%) | 3 updates (25%) |
| 18 updates (37%) | 15 updates (37%) | 12 updates (37%) | 9 updates (37%) | 6 updates (37%) | 3 updates (37%) |



30-05-2013 |

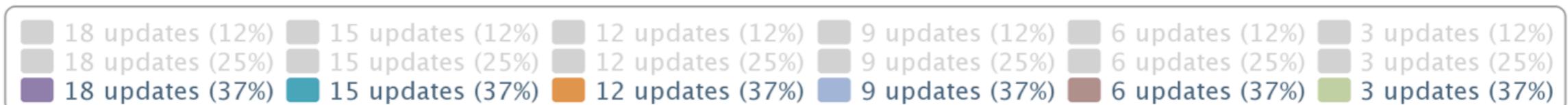
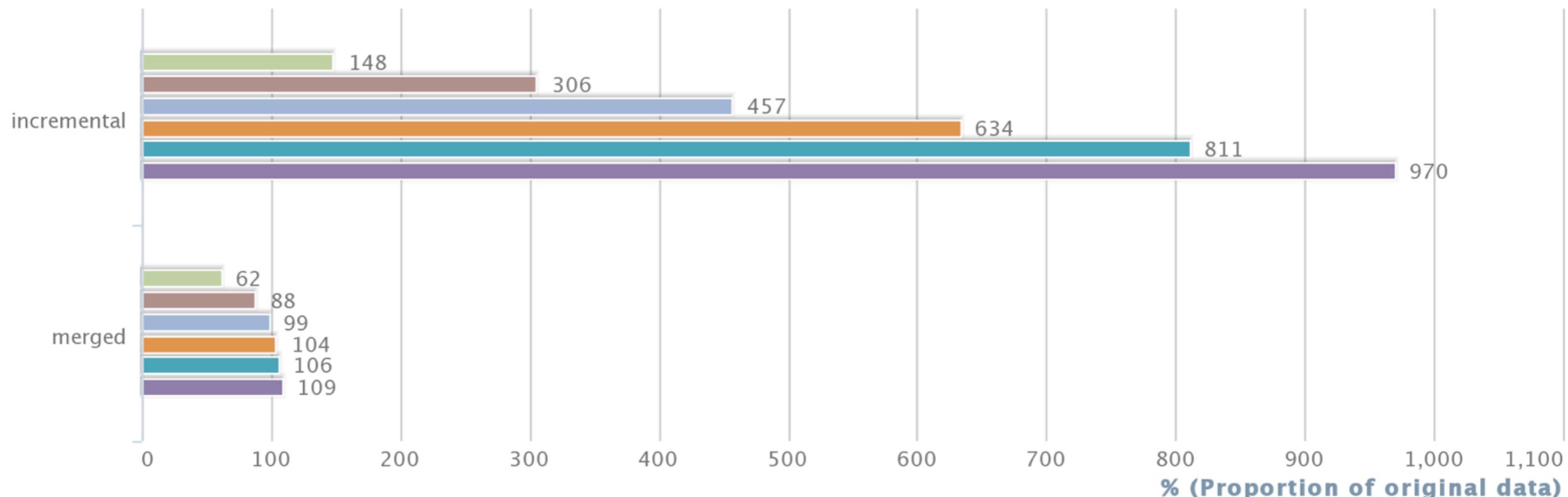
Incremental vs. Merged Browser Log  
Memory footprint for recording local updates [Final Mean]





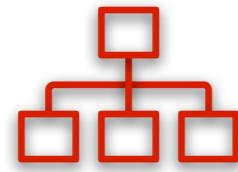
30-05-2013 |

Incremental vs. Merged Browser Log  
Memory footprint for recording local updates [Final Mean]

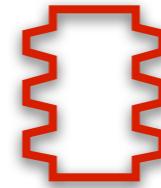




# Results



Network load



Memory footprint



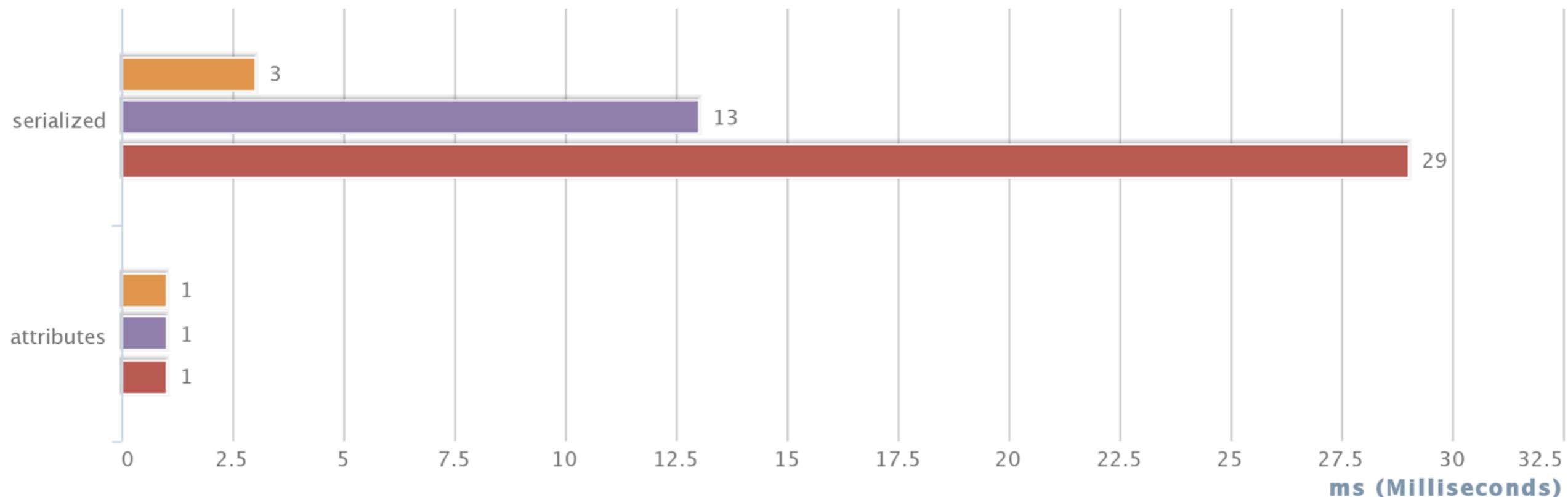
Conflict resolution

► Performance



30-05-2013 |

**Serialized Data vs. Attribute Oriented Approach**  
Performance overhead of recording updates and resolving conflicts [Final Mean]

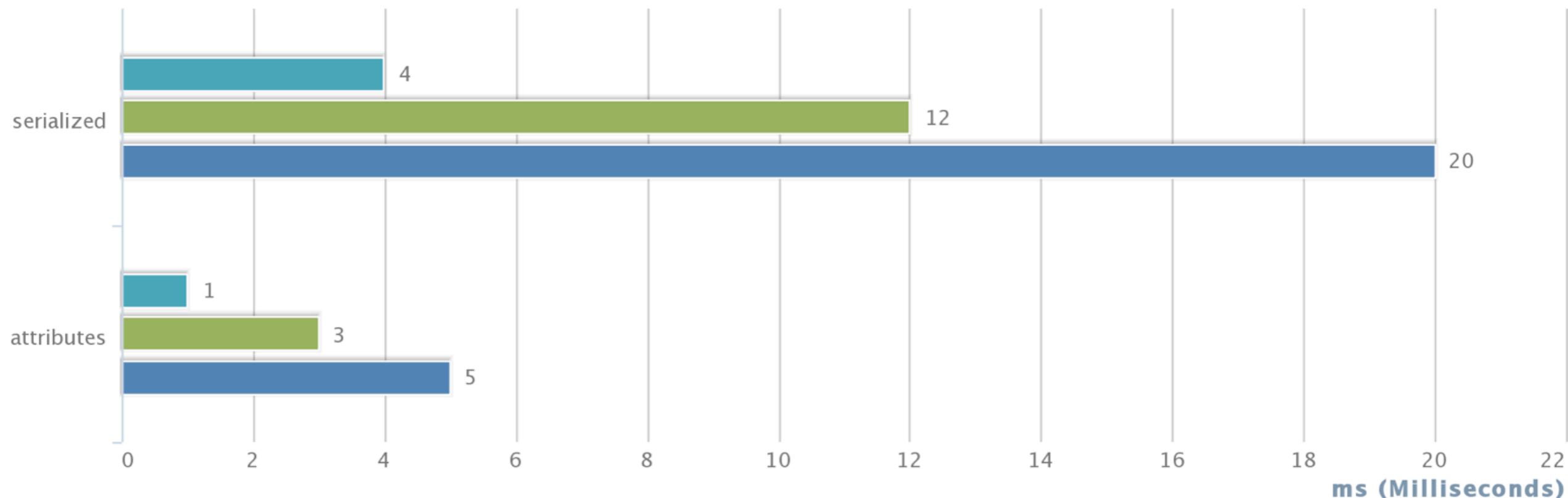


Legend:  
resolve(37%) record(37%) resolve(25%) record(25%) resolve(12%) record(12%)  
resolve 37% (strings & mods only) record 37% (strings & mods only)  
resolve 25% (strings & mods only) record 25% (strings & mods only)  
resolve 12% (strings & mods only) record 12% (strings & mods only)



30-05-2013 |

**Serialized Data vs. Attribute Oriented Approach**  
Performance overhead of recording updates and resolving conflicts [Final Mean]



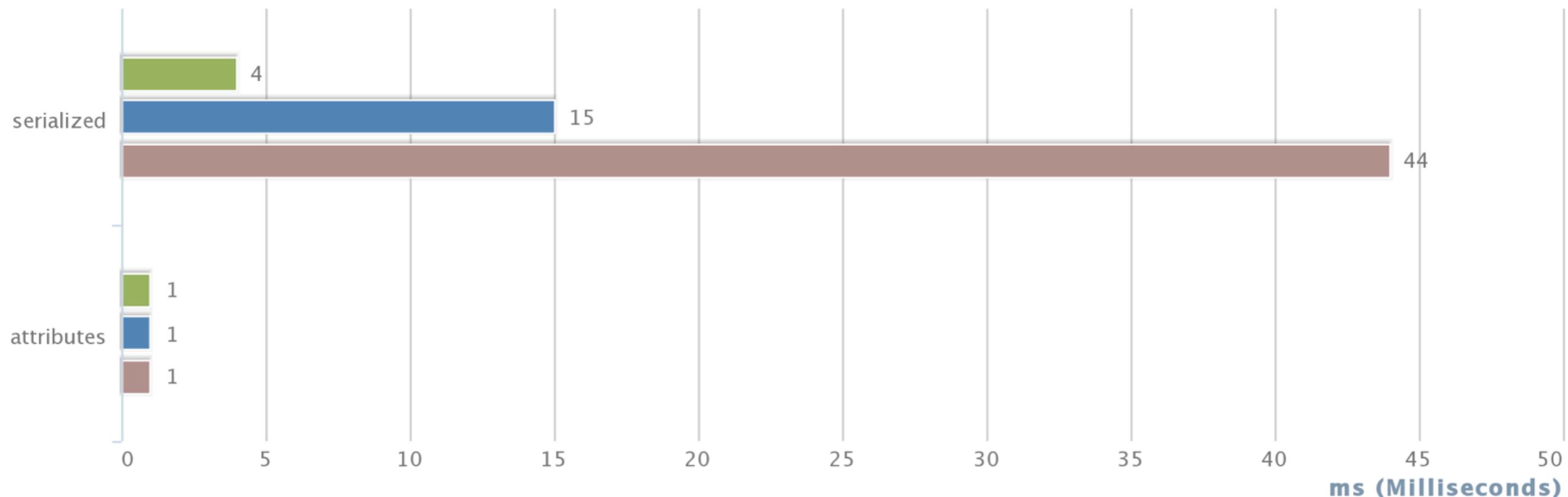
Legend:

- resolve(37%)
- record(37%)
- resolve(25%)
- record(25%)
- resolve(12%)
- record(12%)
- resolve 37% (strings & mods only)
- record 37% (strings & mods only)
- resolve 25% (strings & mods only)
- record 25% (strings & mods only)
- resolve 12% (strings & mods only)
- record 12% (strings & mods only)



30-05-2013 |

**Serialized Data vs. Attribute Oriented Approach**  
Performance overhead of recording updates and resolving conflicts [Final Mean]



Legend:

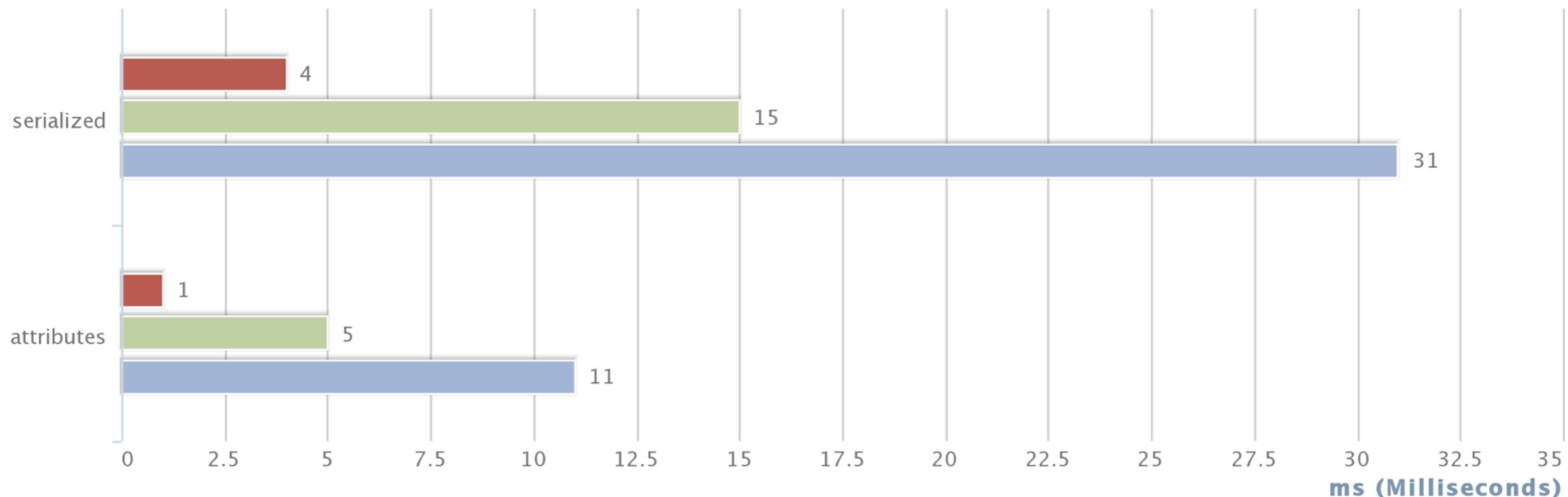
- resolve(37%)
- record(37%)
- resolve(25%)
- record(25%)
- resolve(12%)
- record(12%)
- resolve 37% (strings & mods only)
- record 37% (strings & mods only)
- resolve 25% (strings & mods only)
- record 25% (strings & mods only)
- resolve 12% (strings & mods only)
- record 12% (strings & mods only)



30-05-2013 |

### Serialized Data vs. Attribute Oriented Approach

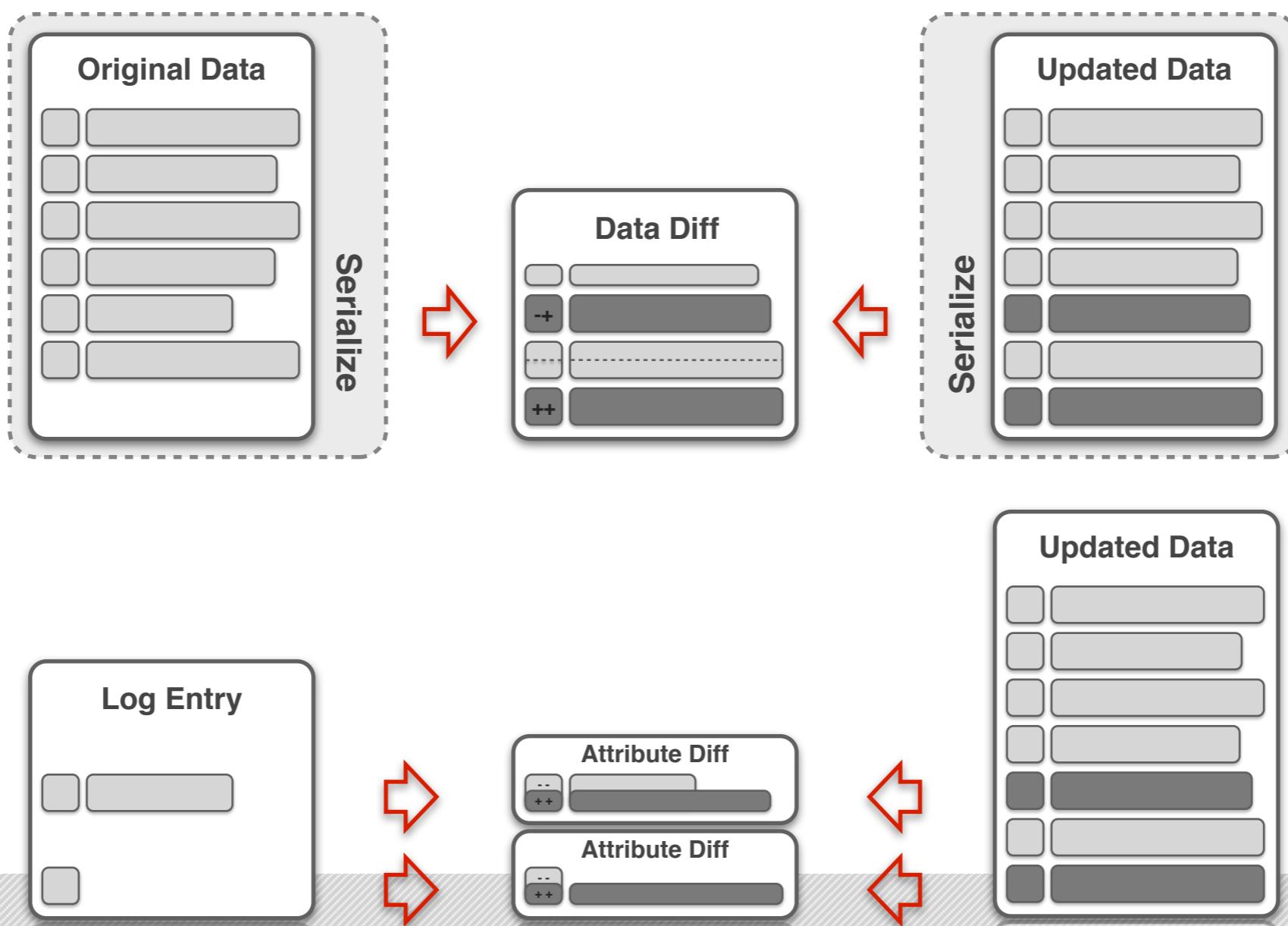
Performance overhead of recording updates and resolving conflicts [Final Mean]



- resolve(37%) ■ record(37%) ■ resolve(25%) ■ record(25%) ■ resolve(12%) ■ record(12%) ■ resolve 37% (strings & mods only)
- record 37% (strings & mods only) ■ resolve 25% (strings & mods only) ■ record 25% (strings & mods only)
- resolve 12% (strings & mods only) ■ record 12% (strings & mods only)

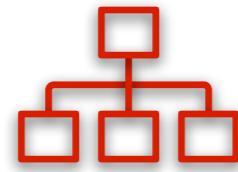


Time complexity:  $O(N + D^2)$

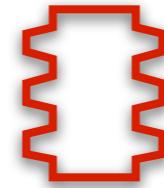




# Results



Network load



Memory footprint

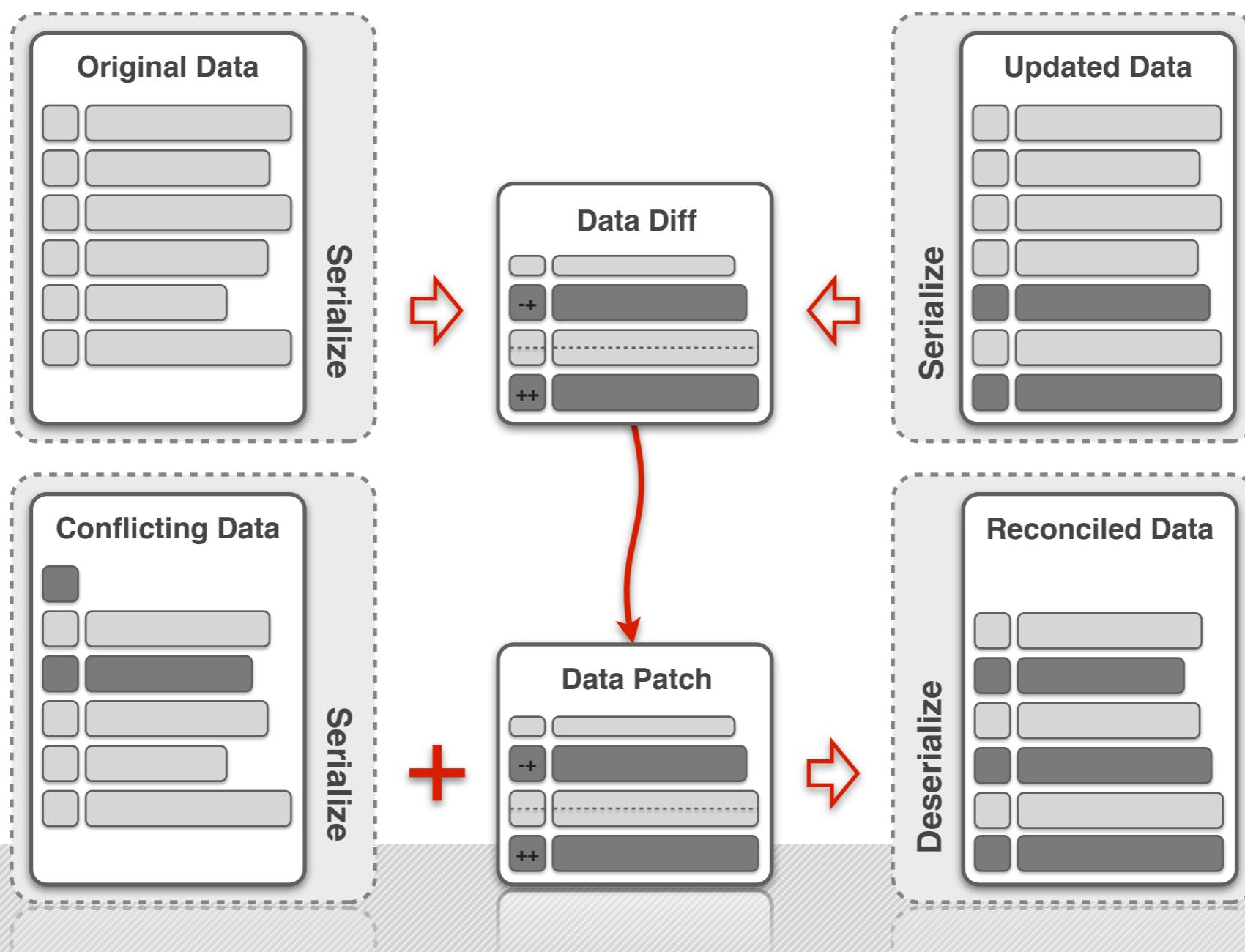


Conflict resolution

- ▶ Performance
- ▶ Resolution rate



# Conflict resolution rate

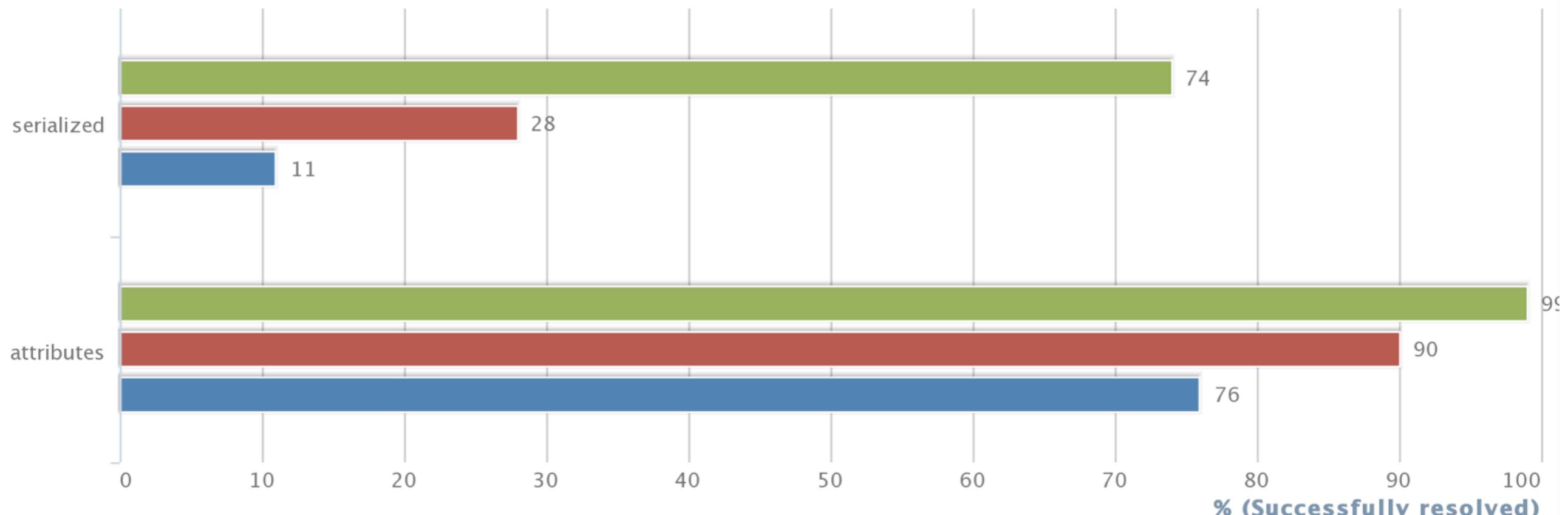




30-05-2013 |

### Serialized Data vs. Attribute Oriented Approach

Proportion successfully resolved conflicts [Final Mean]



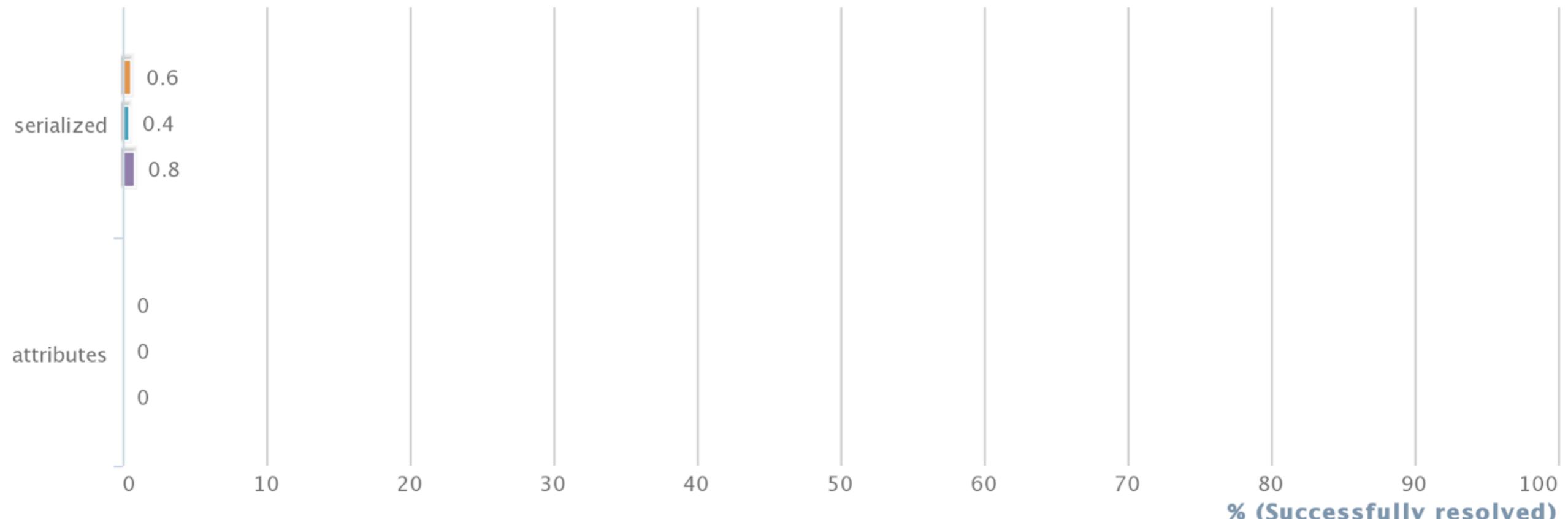
37% 25% 12% 37% (mangled data) 25% (mangled data) 12% (mangled data) 37% (strings only)  
25% (strings only) 12% (strings only) 37% (mods only) 25% (mods only) 12% (mods only)



30-05-2013 |

## Serialized Data vs. Attribute Oriented Approach

Proportion successfully resolved conflicts [Final Mean]



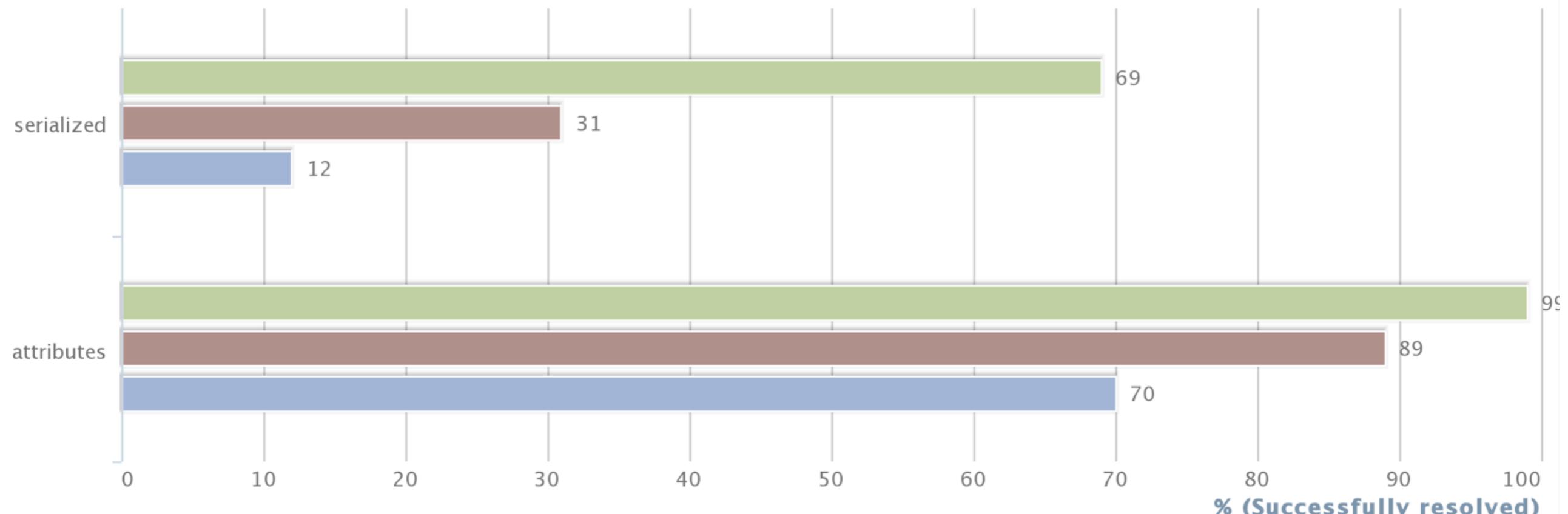
37% 25% 12% 37% (mangled data) 25% (mangled data) 12% (mangled data) 37% (strings only)  
25% (strings only) 12% (strings only) 37% (mods only) 25% (mods only) 12% (mods only)



30-05-2013 |

### Serialized Data vs. Attribute Oriented Approach

Proportion successfully resolved conflicts [Final Mean]



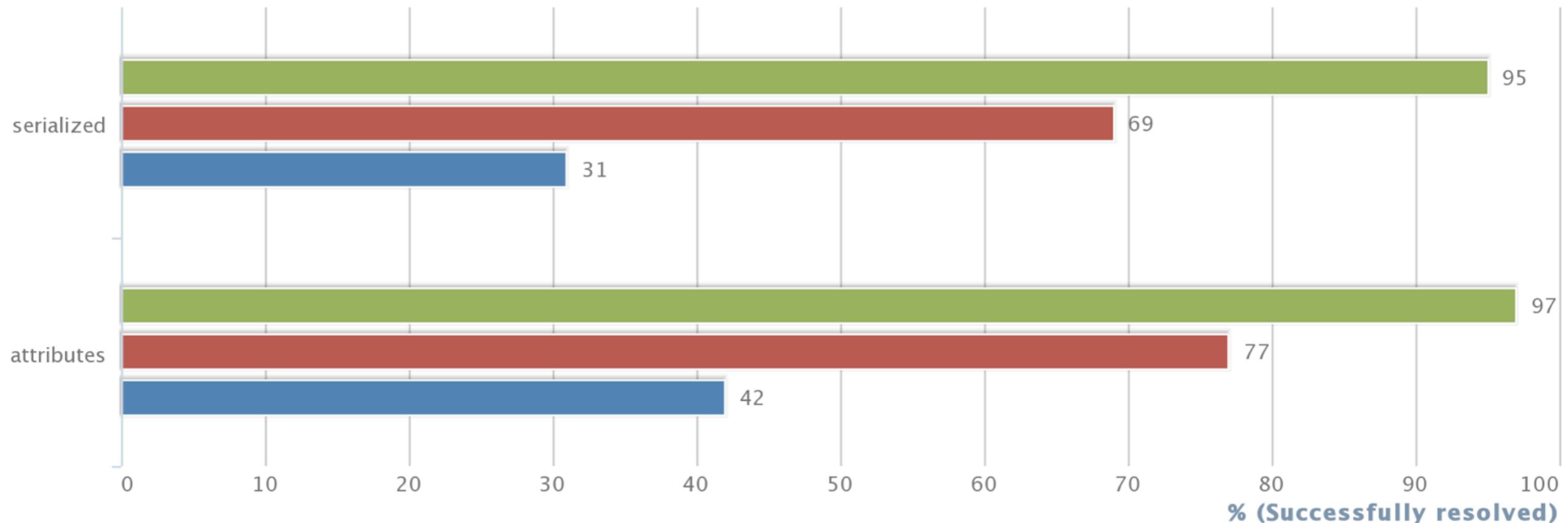
37% 25% 12% 37% (mangled data) 25% (mangled data) 12% (mangled data) 37% (strings only)  
25% (strings only) 12% (strings only) 37% (mods only) 25% (mods only) 12% (mods only)



30-05-2013 |

### Serialized Data vs. Attribute Oriented Approach

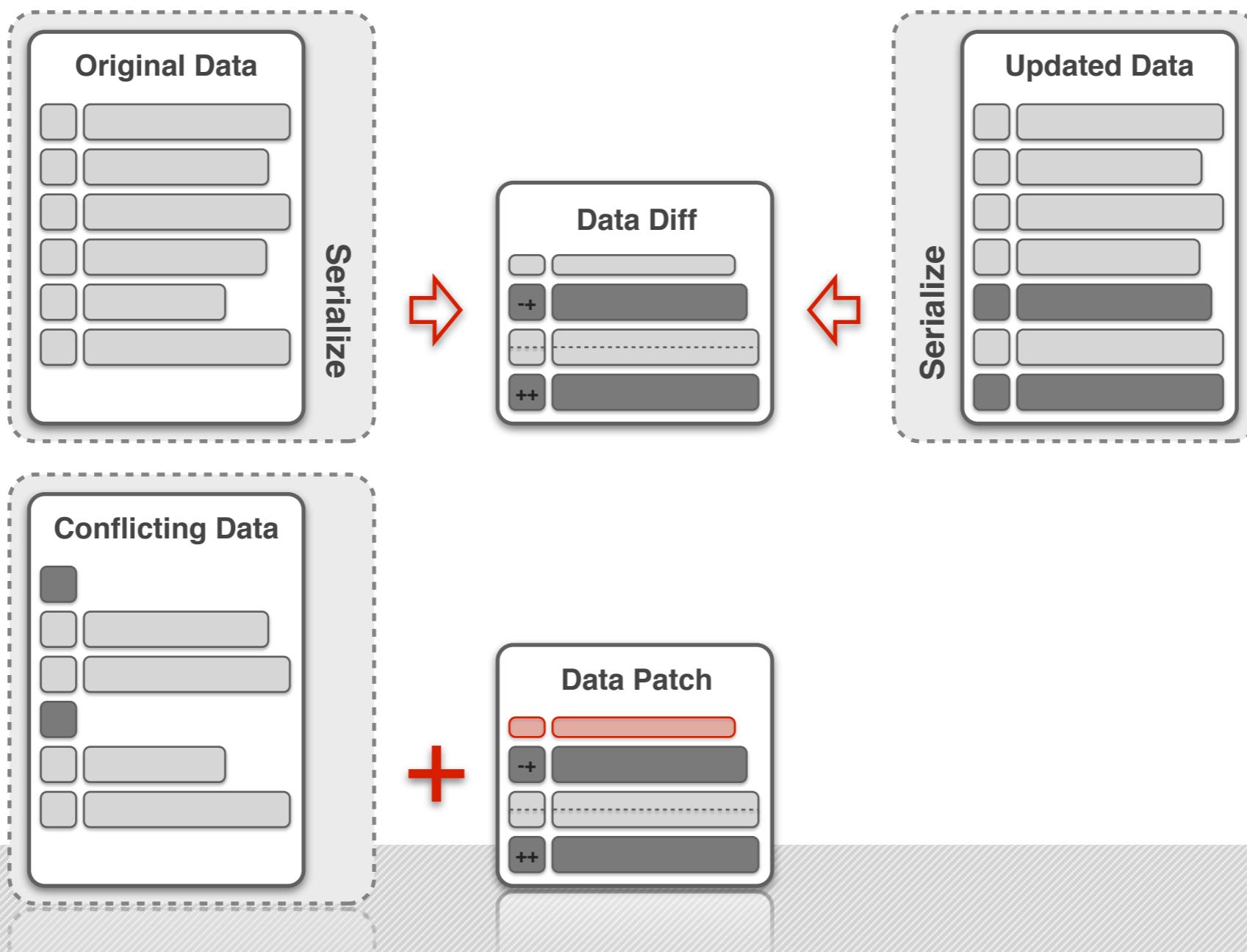
Proportion successfully resolved conflicts [Final Mean]



37% 25% 12% 37% (mangled data) 25% (mangled data) 12% (mangled data) 37% (strings only)  
25% (strings only) 12% (strings only) 37% (mods only) 25% (mods only) 12% (mods only)

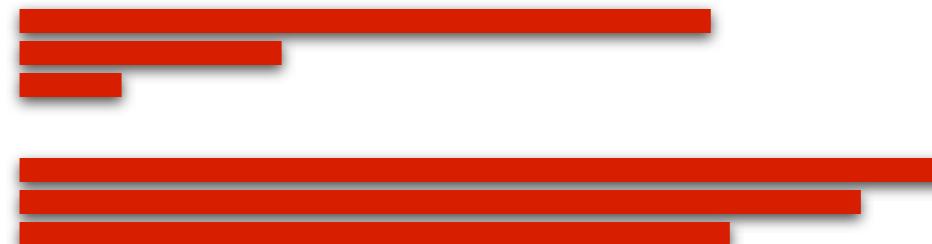
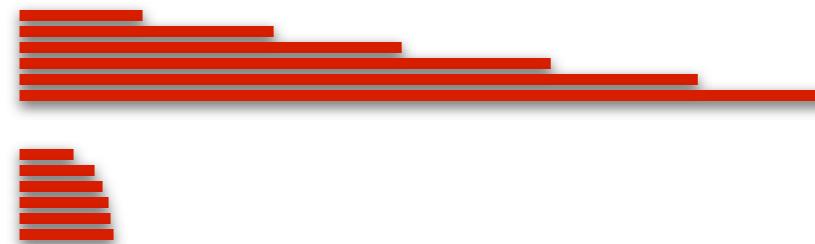
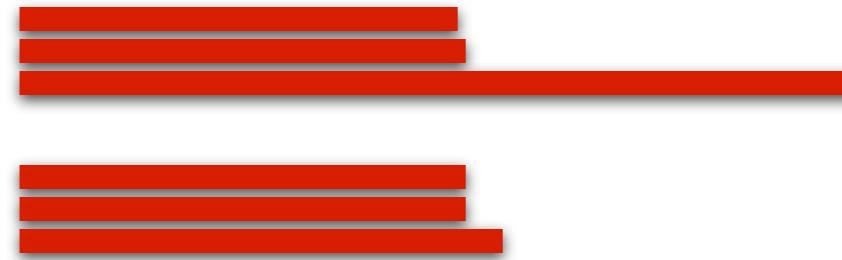
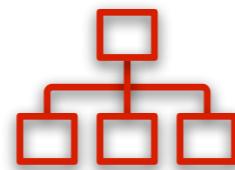


# Context mismatches





# Conclusion





university of  
groningen

faculty of mathematics  
and natural sciences

30-05-2013 |

# Questions?

› [Github.com/krikis/nomad](https://github.com/krikis/nomad)