# Programming
# Weak Synchronization
# Models

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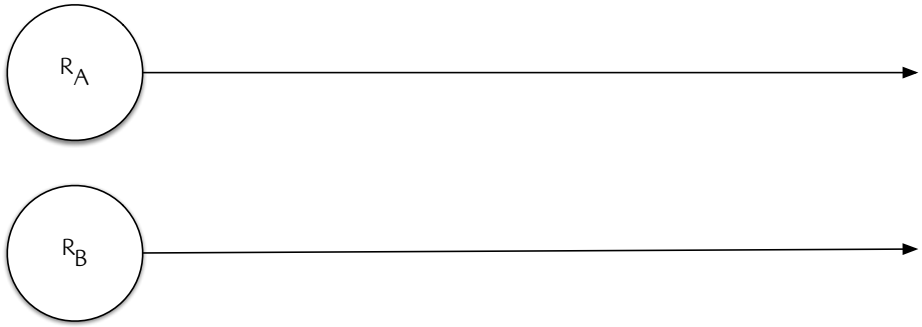
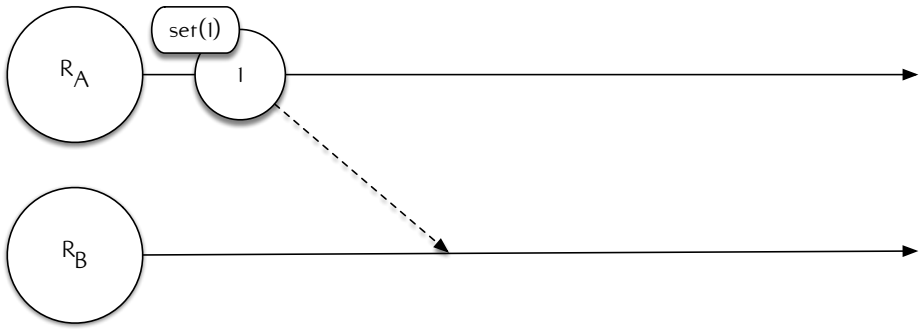
# Example Application
# Advertisement Counter

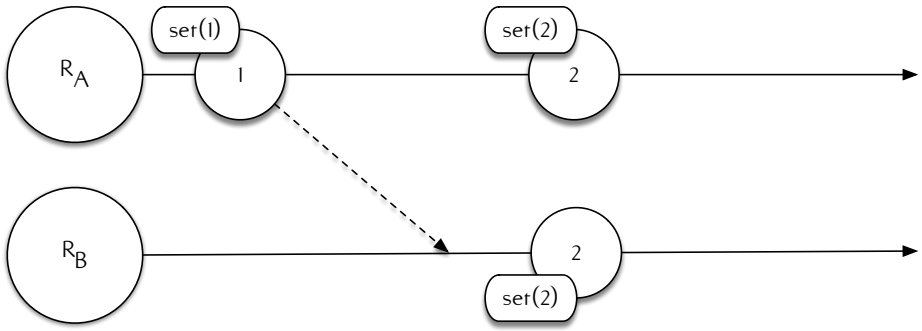
# Advertisement Counter

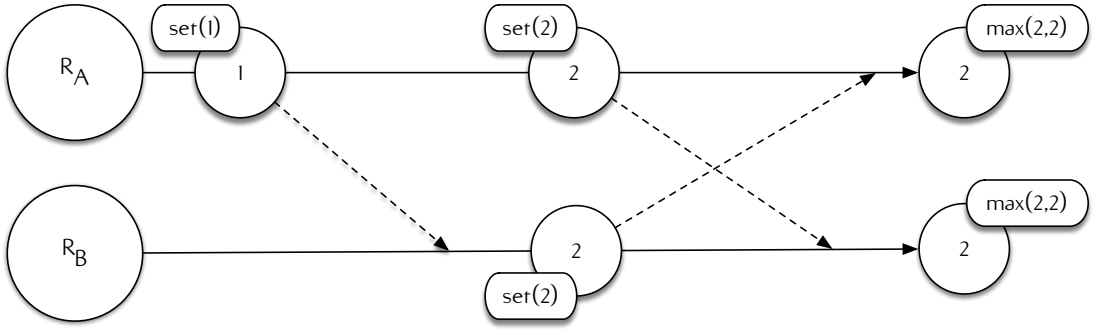
- Lower-bound invariant
  Advertisements are paid according to a minimum number of impressions
- Clients will go offline
  Clients have limited connectivity and the system still needs to make progress while clients are offline
- No lost updates
  All displayed advertisements should be accounted for, with no lost updates

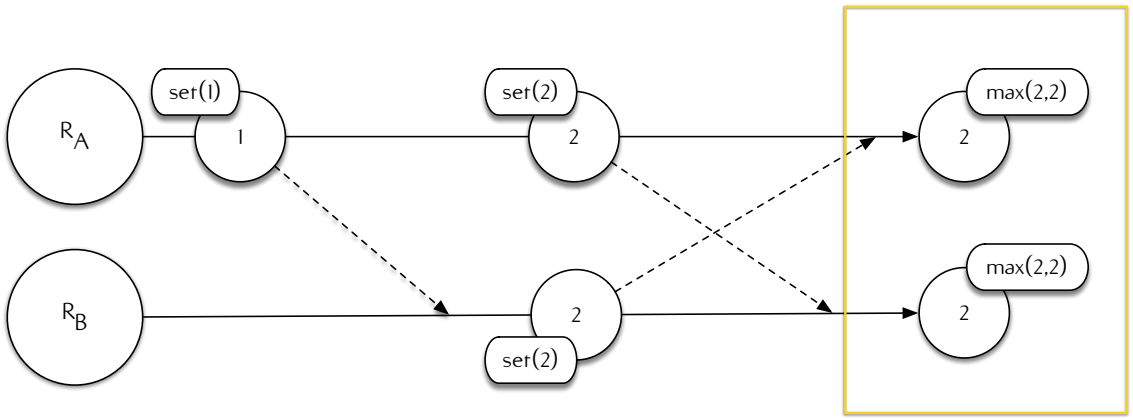
# Advertisement Counter
# Losing Updates


$R_A$
$R_B$


set(1)
$R_A$
1
$R_B$

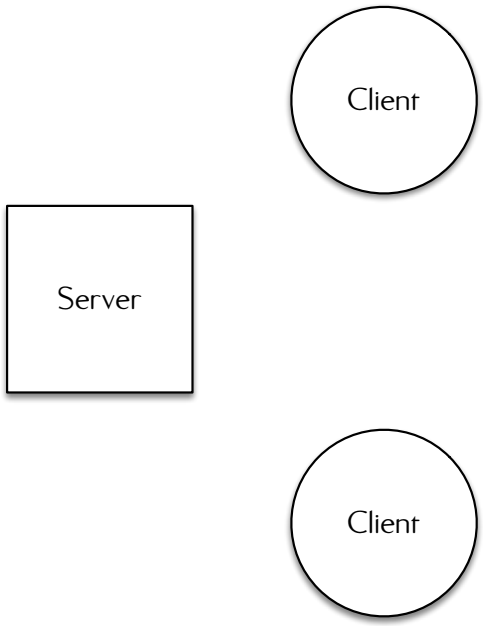

ser(1)
$R_A$
1
ser(2)
2
$R_B$
2
ser(2)

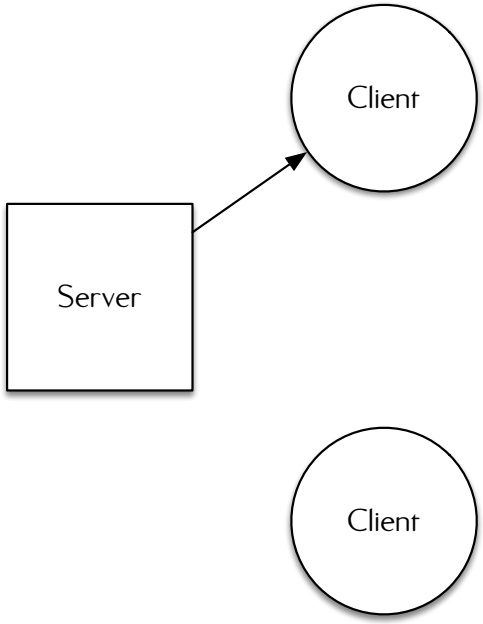

$R_A$
set(1)
1
set(2)
2
max(2,2)
2
$R_B$
2
set(2)
max(2,2)
2



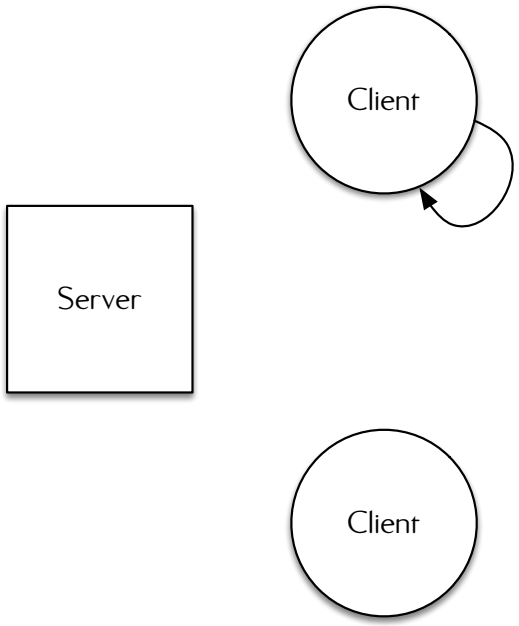

**Incorrect** value is computed because of incompatible lattice.

# Advertisement Counter
# Application Flow

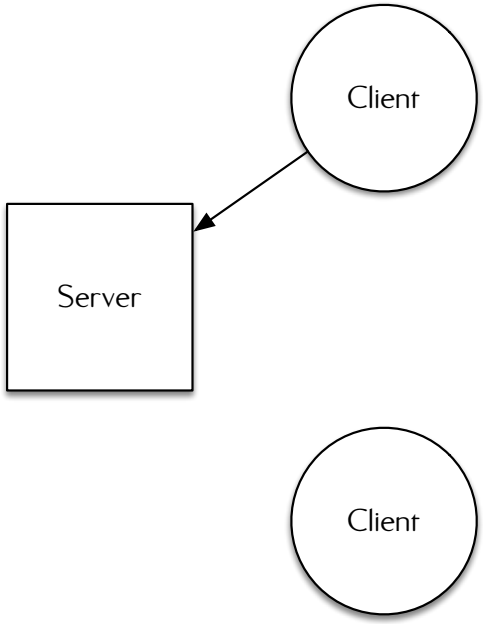

Client
Server
Client



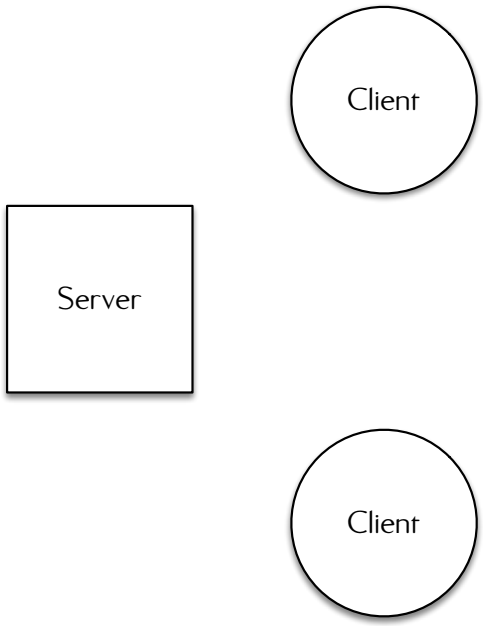

Client
**reads state**
from the server.

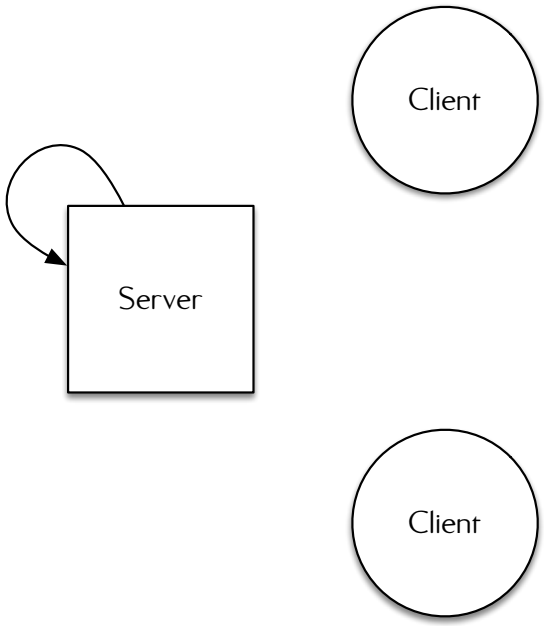



Client
**locally mutates**
state.

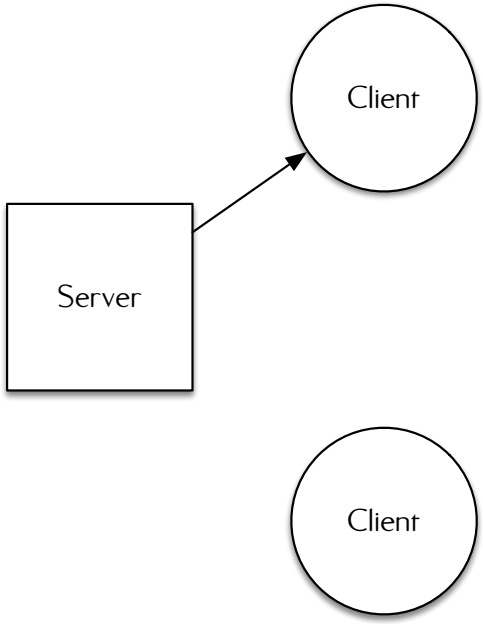



Client
**pushes changes**
back to
the server.

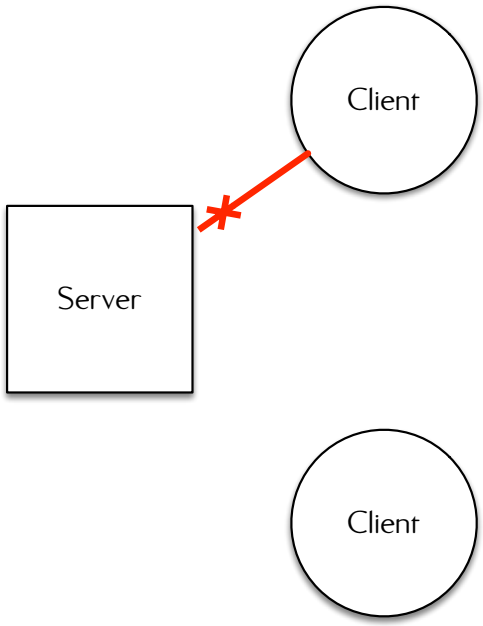

Client
Server
Client




Server
**enforces invariants**
over state.

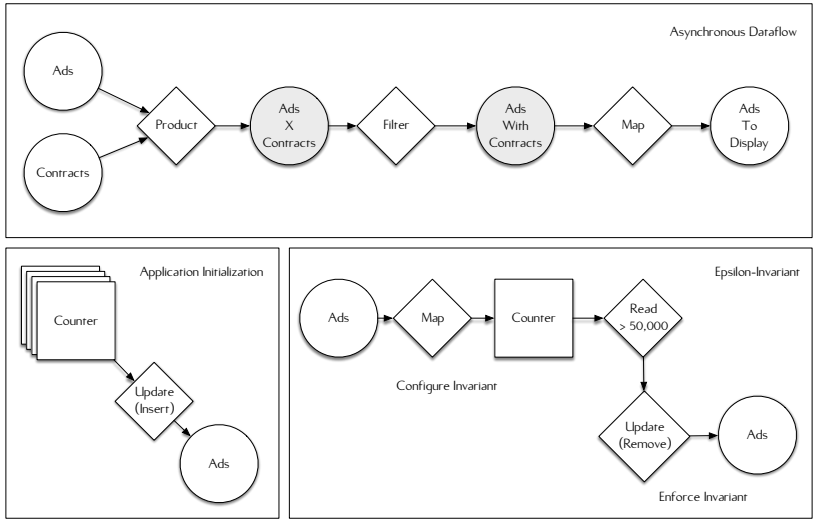


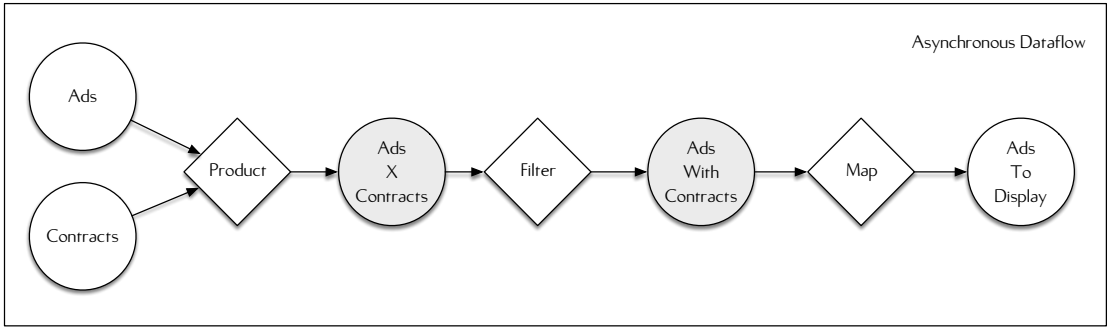

Client retrieves updated state **periodically.**




Clients
unable to communicate
may
violate invariant.

# Advertisement Counter
# Application Design


Asynchronous Dataflow
Ads
Contracts
Product
Ads
X
Contracts
Filter
Ads
With
Contracts
Map
Ads
To
Display
Application Initialization
Counter
Update
(Insert)
Ads
Epsilon-Invariant
Ads
Map
Counter
Read
> 50,000
Configure Invariant
Update
(Remove)
Ads
Enforce Invariant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Ads
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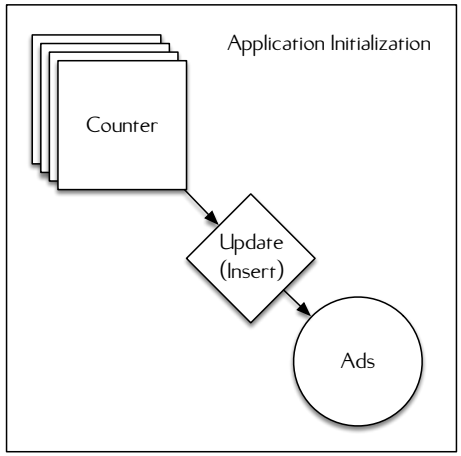
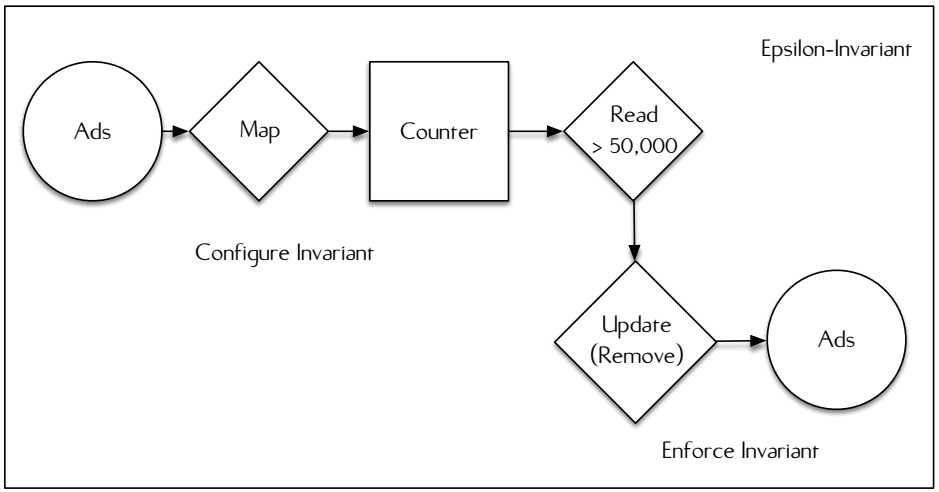
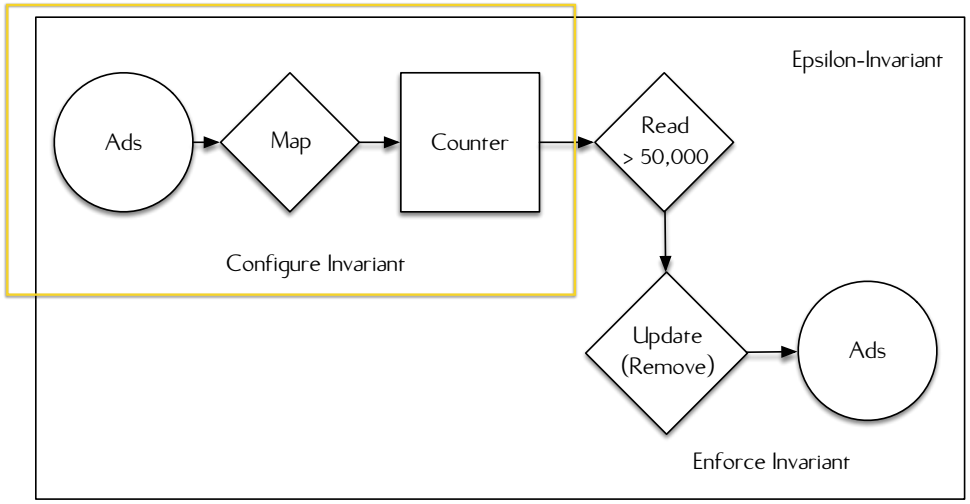
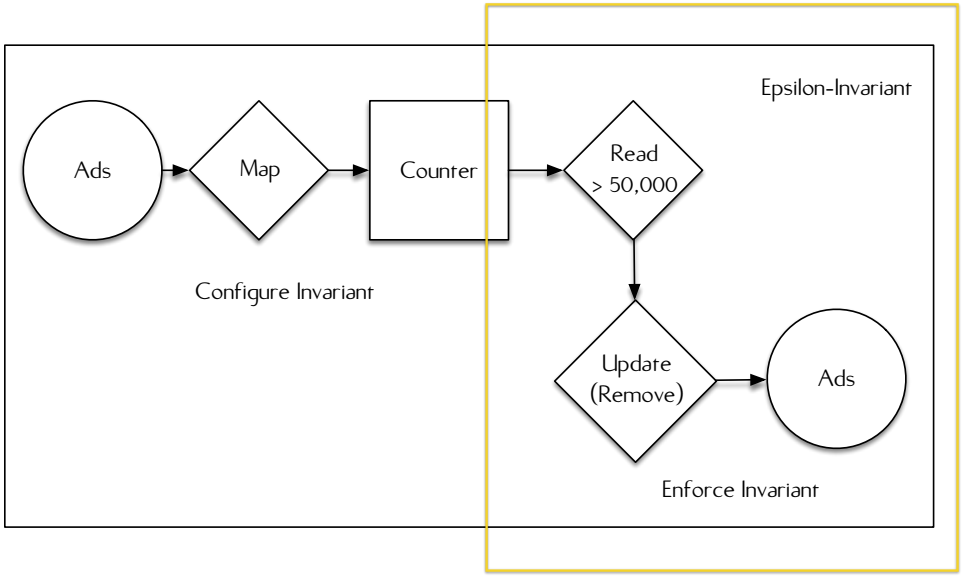

Application Initialization
Counter
Update
(Insert)
Ads


Epsilon-Invariant
Ads
Map
Counter
Read
> 50,000
Configure Invariant
Update
(Remove)
Ads
Enforce Invariant

Configure **invariants** for all of the advertisements.






**Remove** the advertisement from the list.

# Advertisement Counter

- Completely monotonic
  Disabling advertisements and contracts are all modeled through monotonic state growth
- Arbitrary distribution
  Use of convergent data structures allows computational graph to be arbitrarily distributed
- Divergence
  Divergence is a factor of synchronization period, concurrency, and throughput rate

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