Windows Azure Storage – A Highly Available Cloud Storage Service with Strong Consistency

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http://blogs.msdn.com/b/windowsazure/archive/2011/11/21/windows-azure-storage-a-highly-available-cloud-storage-service-with-strong-consistency.aspx

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Windows Azure Storage

- Scalable cloud storage
- In production since November 2008
- Strong consistency
- Global and scalable namespace/storage
- Disaster recovery

Windows Azure Storage Data Abstraction

- Blobs - File system in the cloud
- Tables - Massively scalable structured storage
- Queues - Reliable storage and delivery of messages

Global Partitioned Namespace

http(s)://**AccountName**.<service>.core.windows.net/**PartitionName/ObjectName**

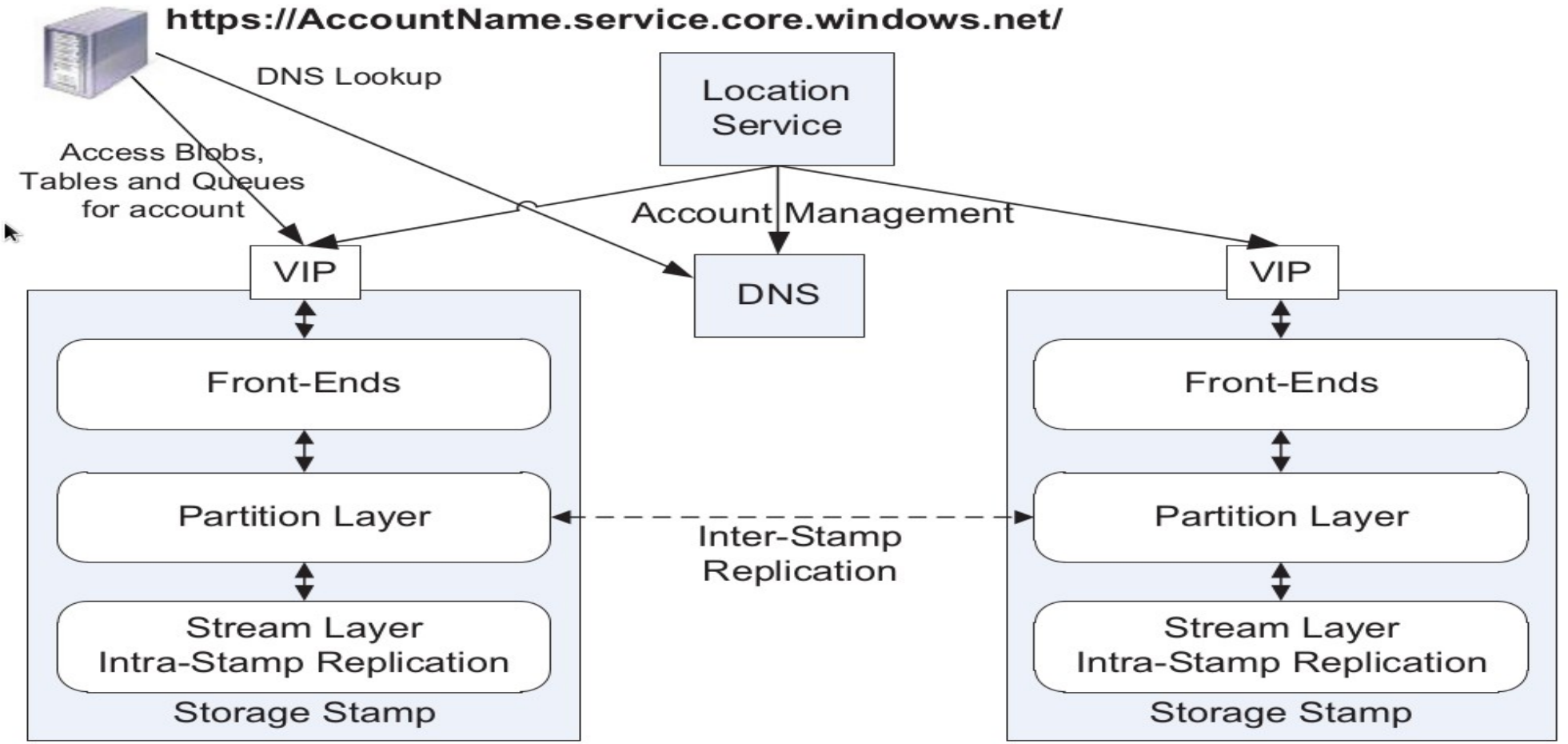
-<service> specifies the service type, which can be **blob, table,** or **queue**

High Level Architecture

Design Goals

- Highly Available with Strong Consistency
  - Provide access to data in face of failures/partitioning
- Durability
  - Replicate data several times within and across data centers
- Scalability
  - Need to scale to exabytes and beyond
  - Provide a global namespace to access data around the world
  - Automatically load balance data to meet peak traffic demands

High Level Architecture



Storage Stamp

- Cluster of 10 to 20 racks of starage nodes
- Each rack is built out as a seperate fault domain
- 18 disk-heavy storage nodes per rack
- 70% utilized in terms of capacity, transaction and bandwidth

Stream Layer

- Append-only distributed file system
- All data from the Partition Layer is stored into files(extents consisting of blocks) in the Stream Layer
- Each extent is repliacated 3 times(Intra-Stamp Replication)
- Does not understand higher level object(blob, table, queue)

Partition Layer

- Manages and understands high level data abstraction
- Uses Stream Layer interface to read and store objects in Stream Layer.
- Provides Inter-Stamp Repliaction
- Provides scalability by partitioning all of the data objects within a stamp

Front-End layer

- Consists of a set of stateless servers
- Authenticates and authorizes the request
- Routes the request to a partition server in the partition layer

Location Service

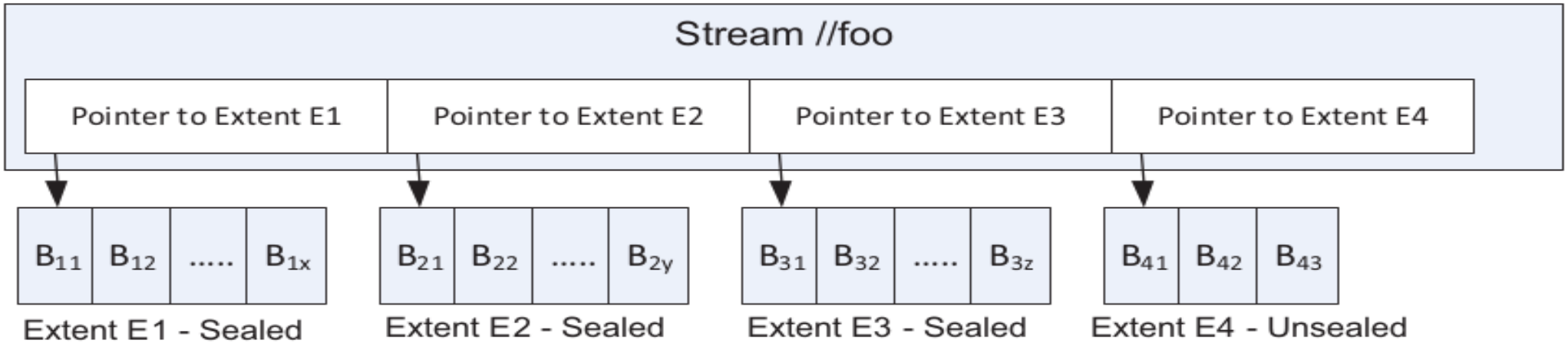
- Manages all the storage stamps
- Allocates accounts to storage stamps
- Distributed across two geographic locations for its own disaster recovery
- Ability to add new storage stamps

Stream Layer

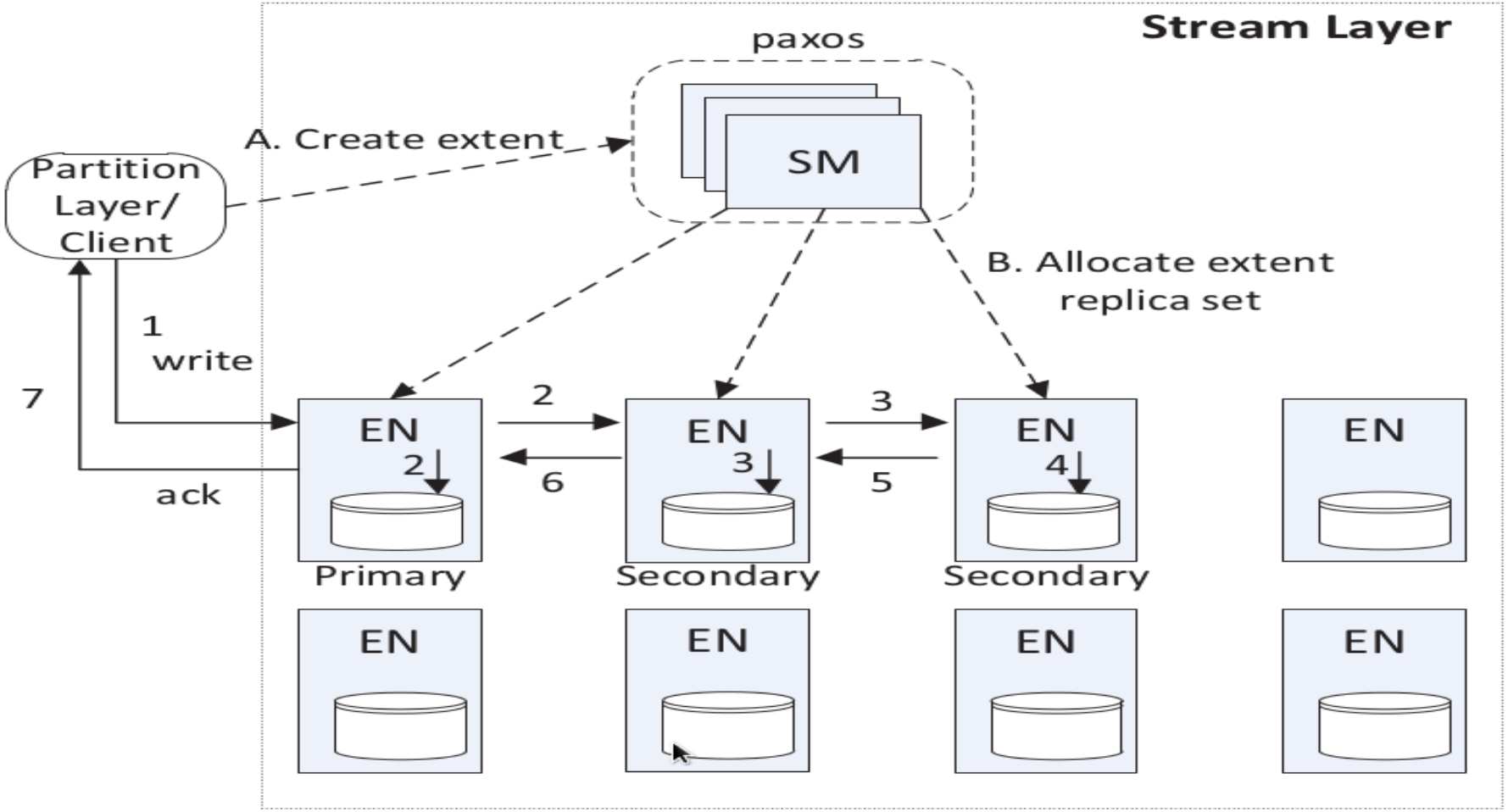
Stream Layer

- Append-Only Distributed File System
- Streams are very large files
  - Has file system like directory namespace
- Stream Operations
  - Open, Close, Delete Streams
  - Rename Streams
  - Concatenate Streams together
  - Append for writing
  - Random reads

Stream Layer Concept



Stream Manager and Extent Nodes



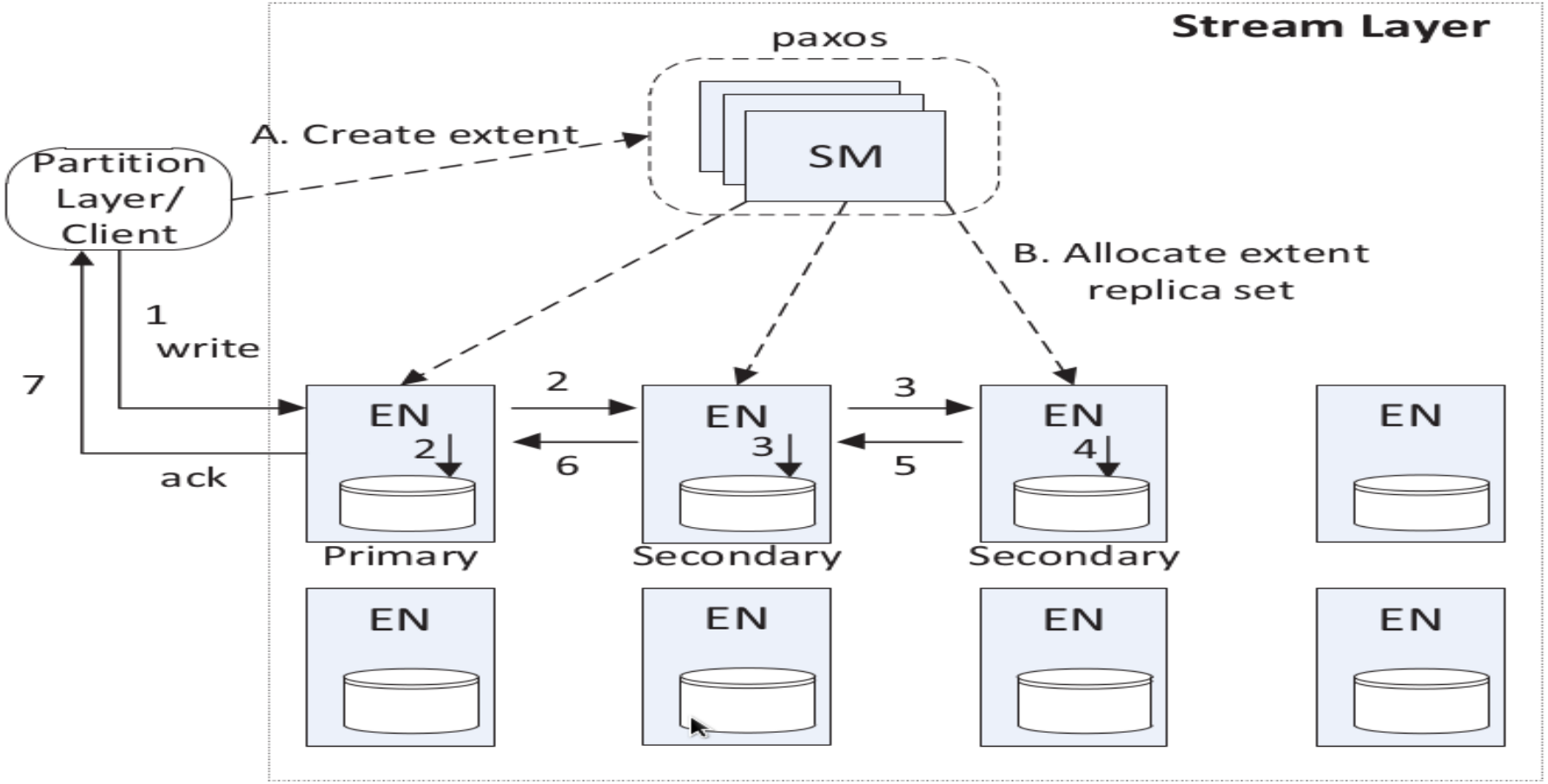
Stream Manager

- Keeps track of the stream namespace, what extent are in each stream, and the extent allocation across the Extent Nodes.
- Performs lazy re-replication of extent
- Monitors health of the Extent Nodes

Extent Node

- Maintains the storage for a set of extent replicas
- Deals only with extents and blocks
- Talks only to other Extent Nodes

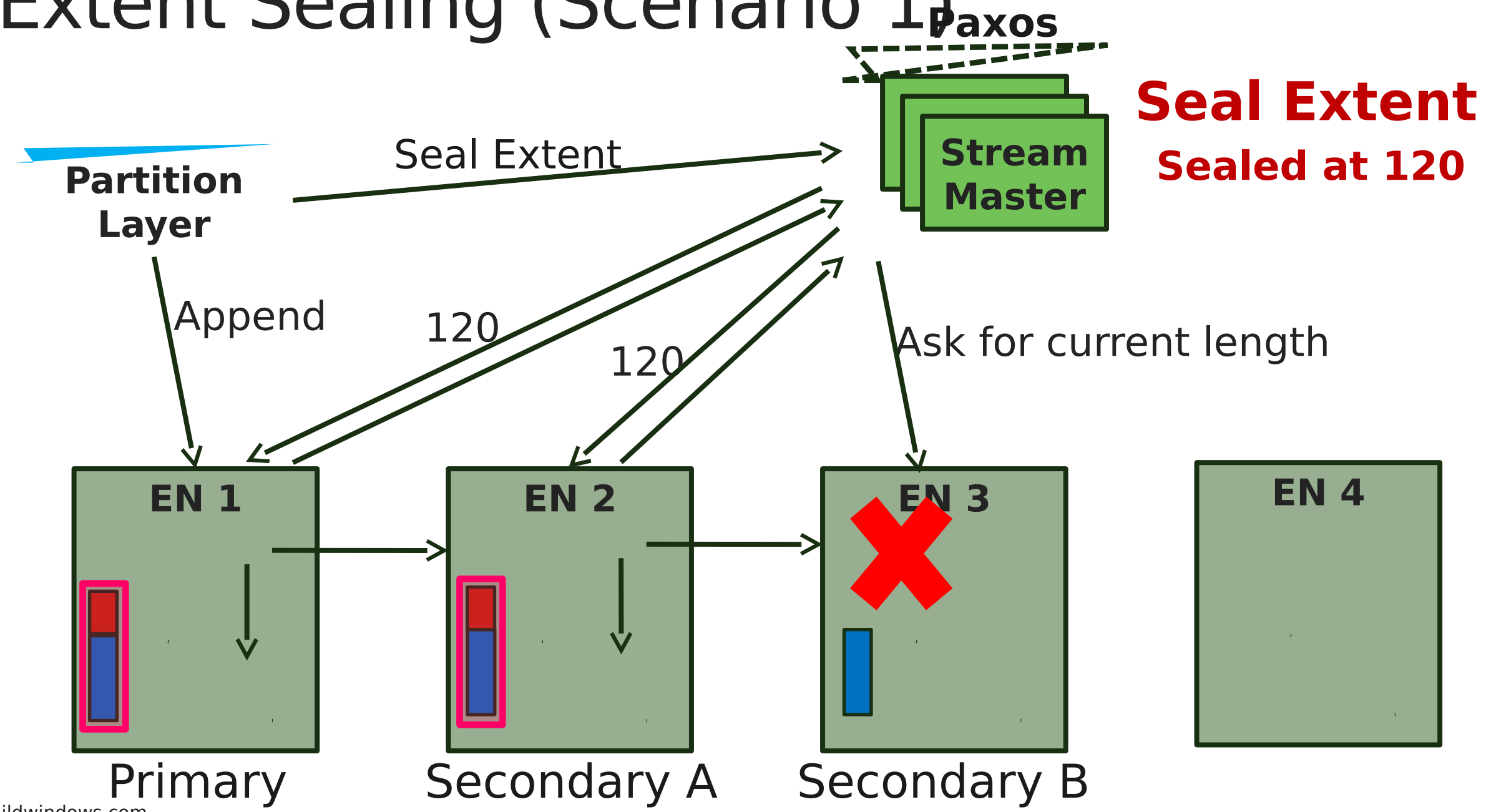
Stream Layer Intra-Stamp Replication



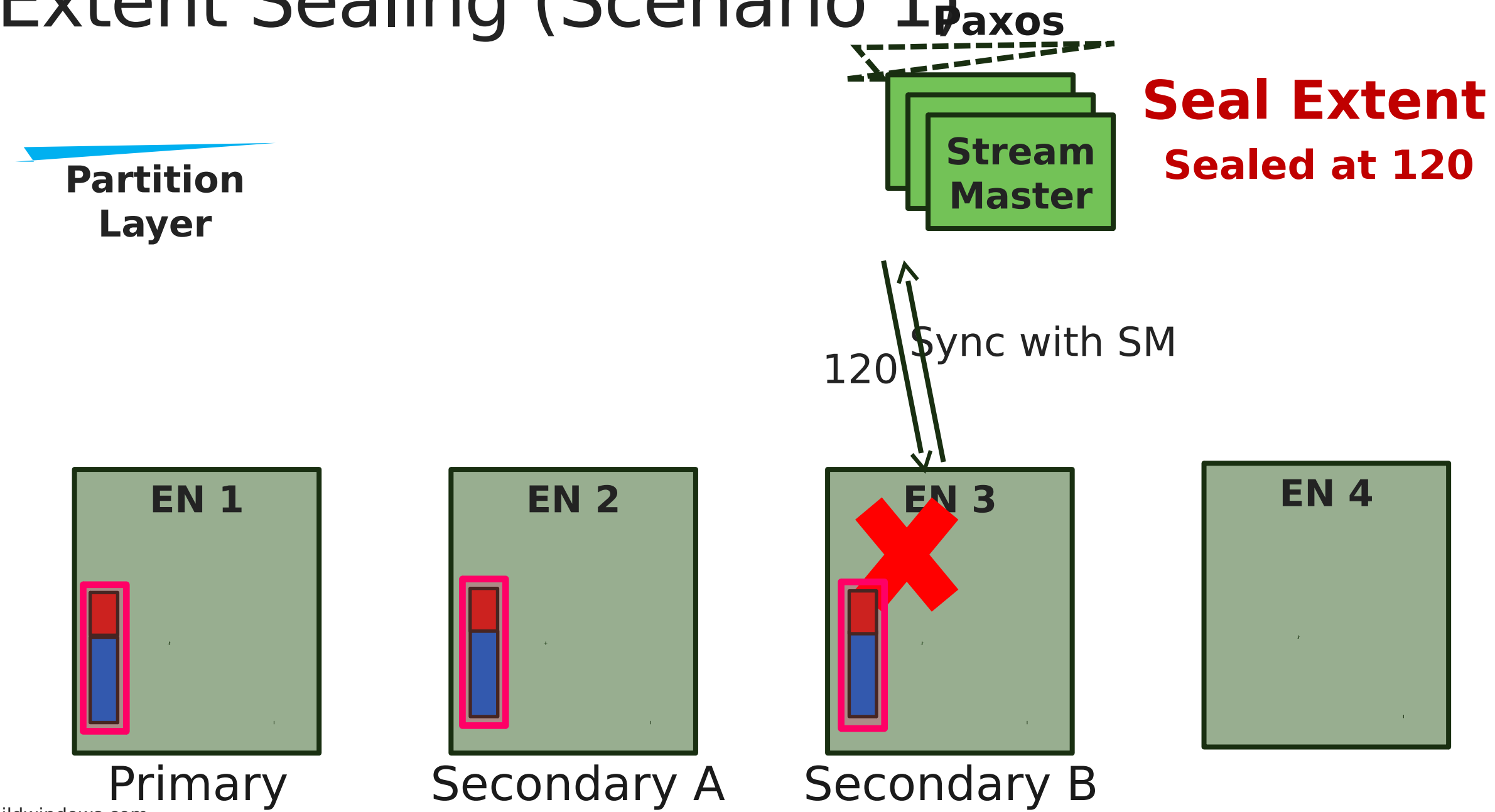
Providing Bit-wise identical replica

- Primary Extent Node for an extent never changes
- Primary Extent Node always picks the offset for appends
- Append for an extent are committed in order
- Sealing strategy

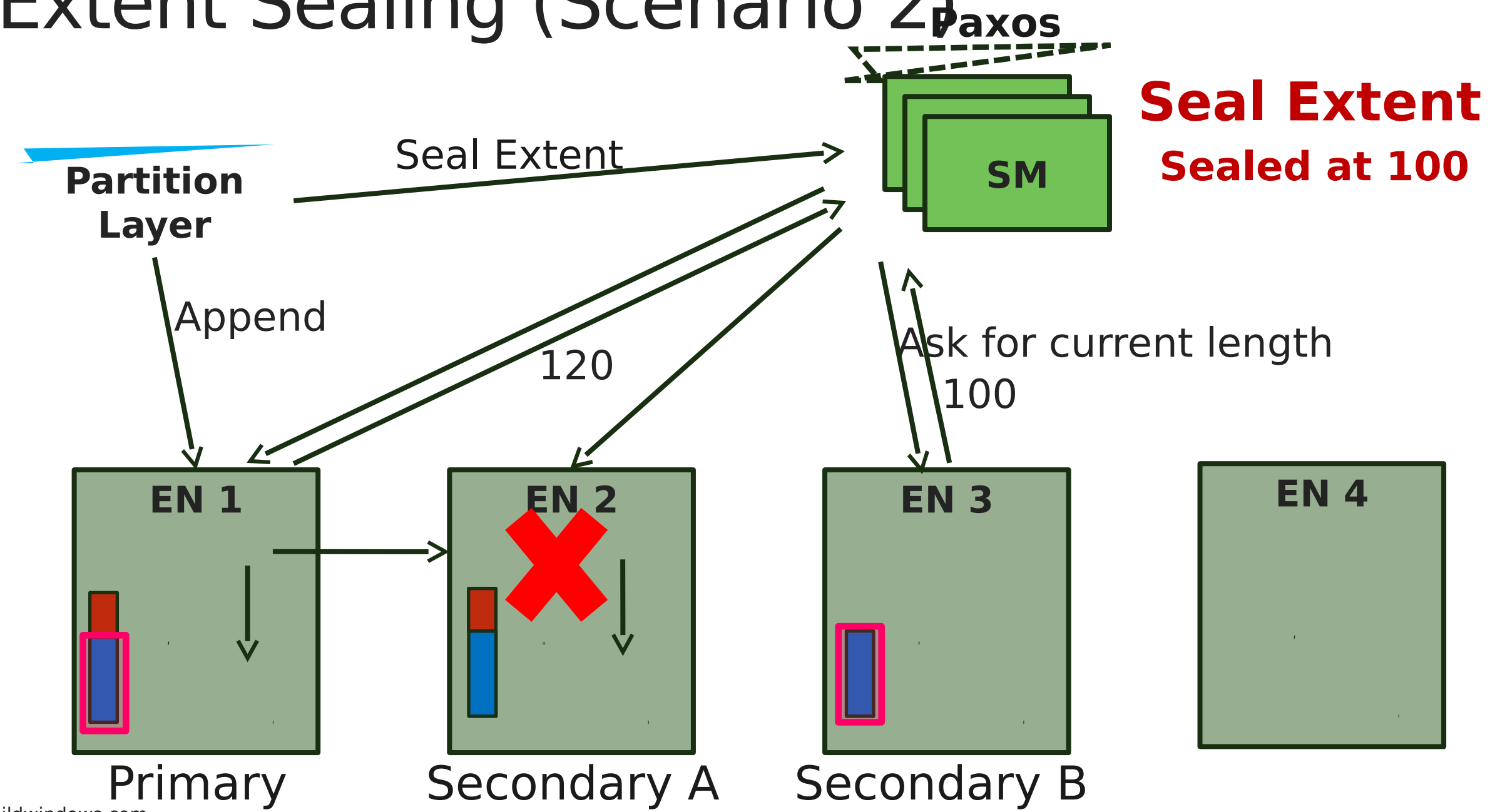
Extent Sealing (Scenario 1)



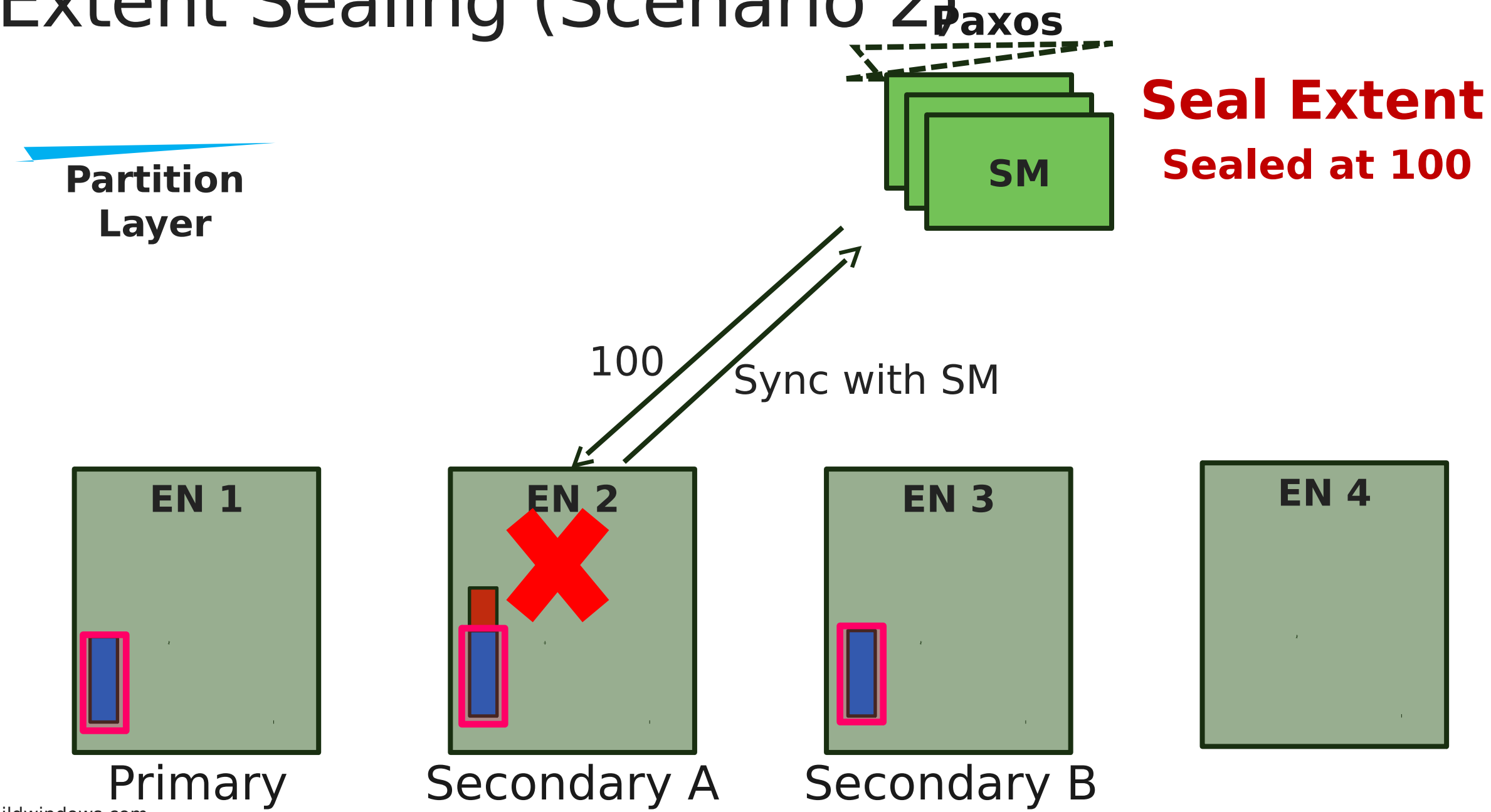
Extent Sealing (Scenario 1)



Extent Sealing (Scenario 2)

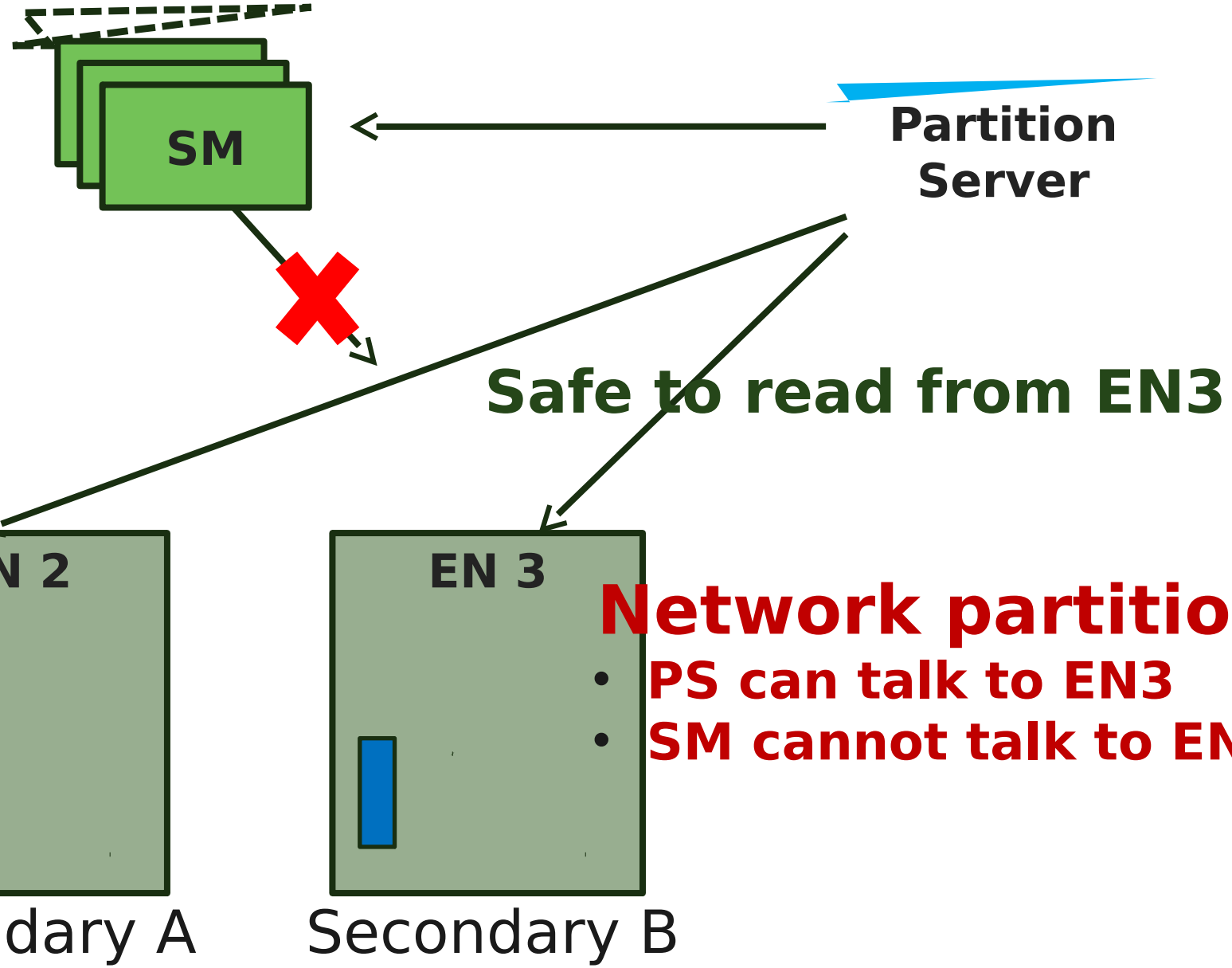


Extent Sealing (Scenario 2)



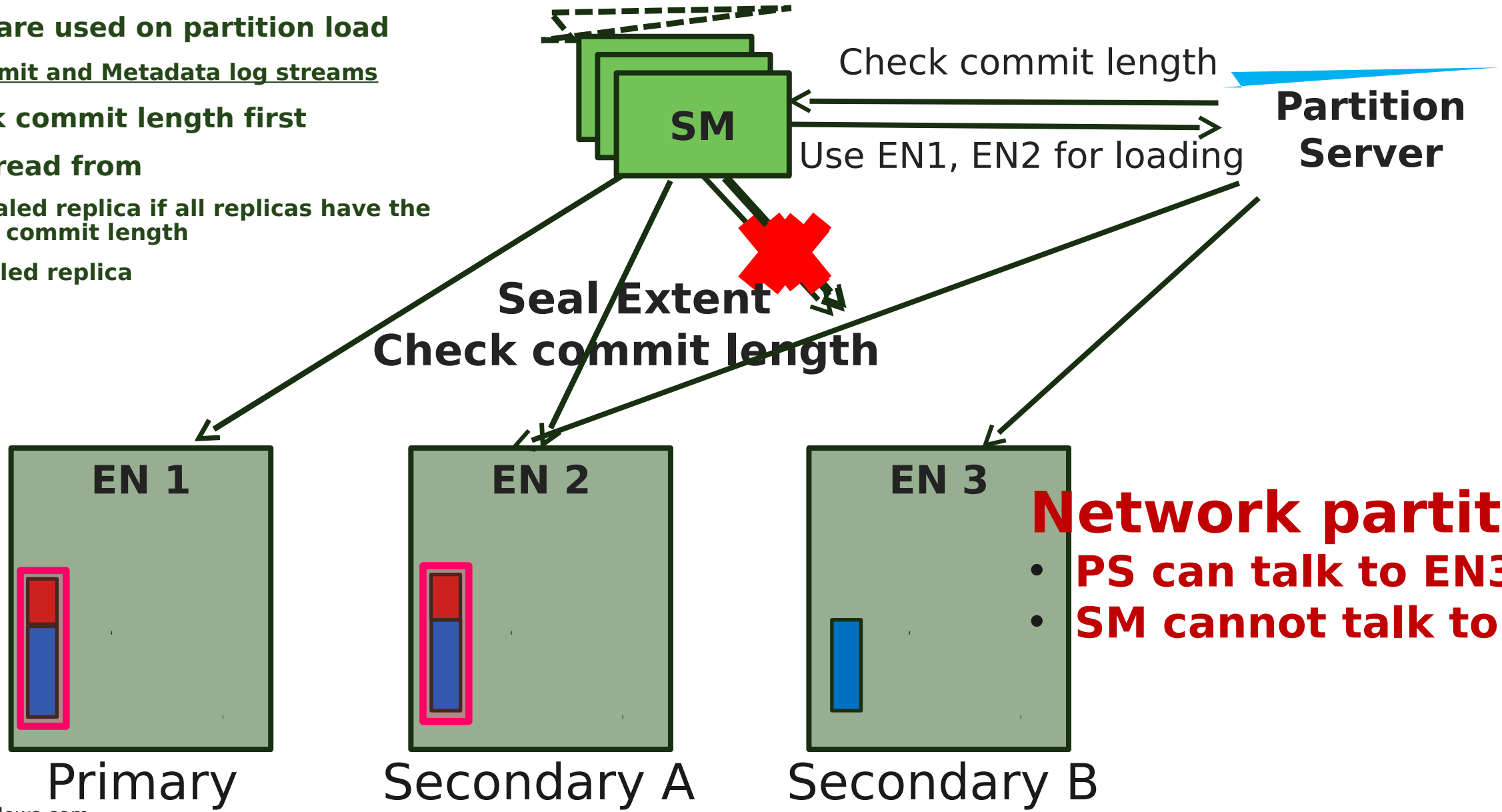
Providing Consistency for **Data Streams**

- **For Data Streams, Partition Layer only reads from offsets returned from successful appends**
  - **Committed on all replicas**
  - **Row and Blob Data Streams**
- **Offset valid on any replica**



Providing Consistency for **Log Streams**

- **Logs are used on partition load**
  - **Commit and Metadata log streams**
- **Check commit length first**
- **Only read from**
- **Unsealed replica if all replicas have the same commit length**
- **A sealed replica**



Network partitio

- **PS can talk to EN3**
- **SM cannot talk to EN**

Durability and Journaling

- Three durable copies of the data stored in system
- On each Extend Node a whole disk is reserved as a **journal drive**
- The journal drive is dedicated solely for writing

Partition Layer

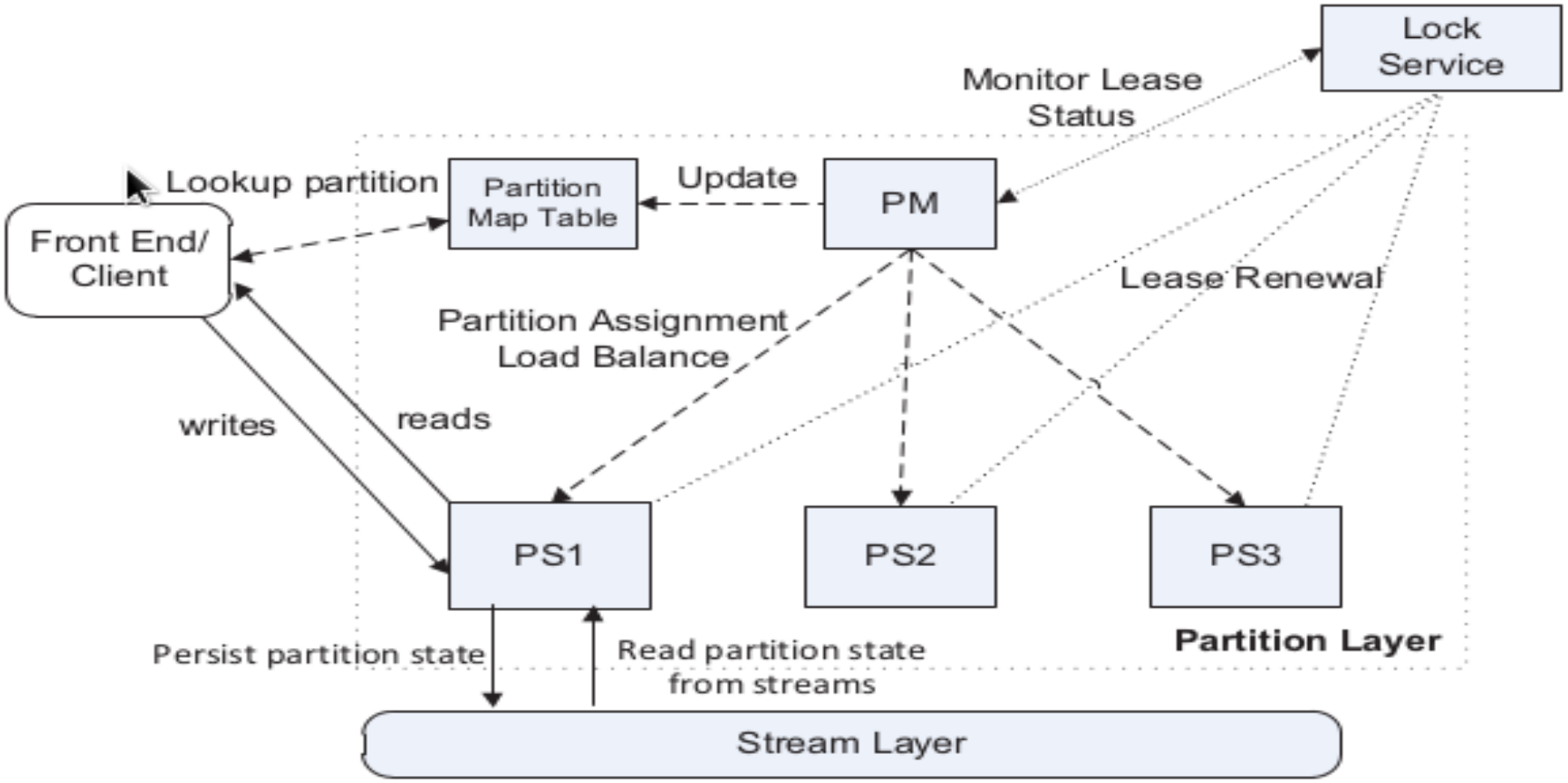
Partition Layer

- Stores different types of objects (blob, table or queue)
- Understands what a transaction means for a given object type
- Spread the index across many servers
- Dynamically load balance

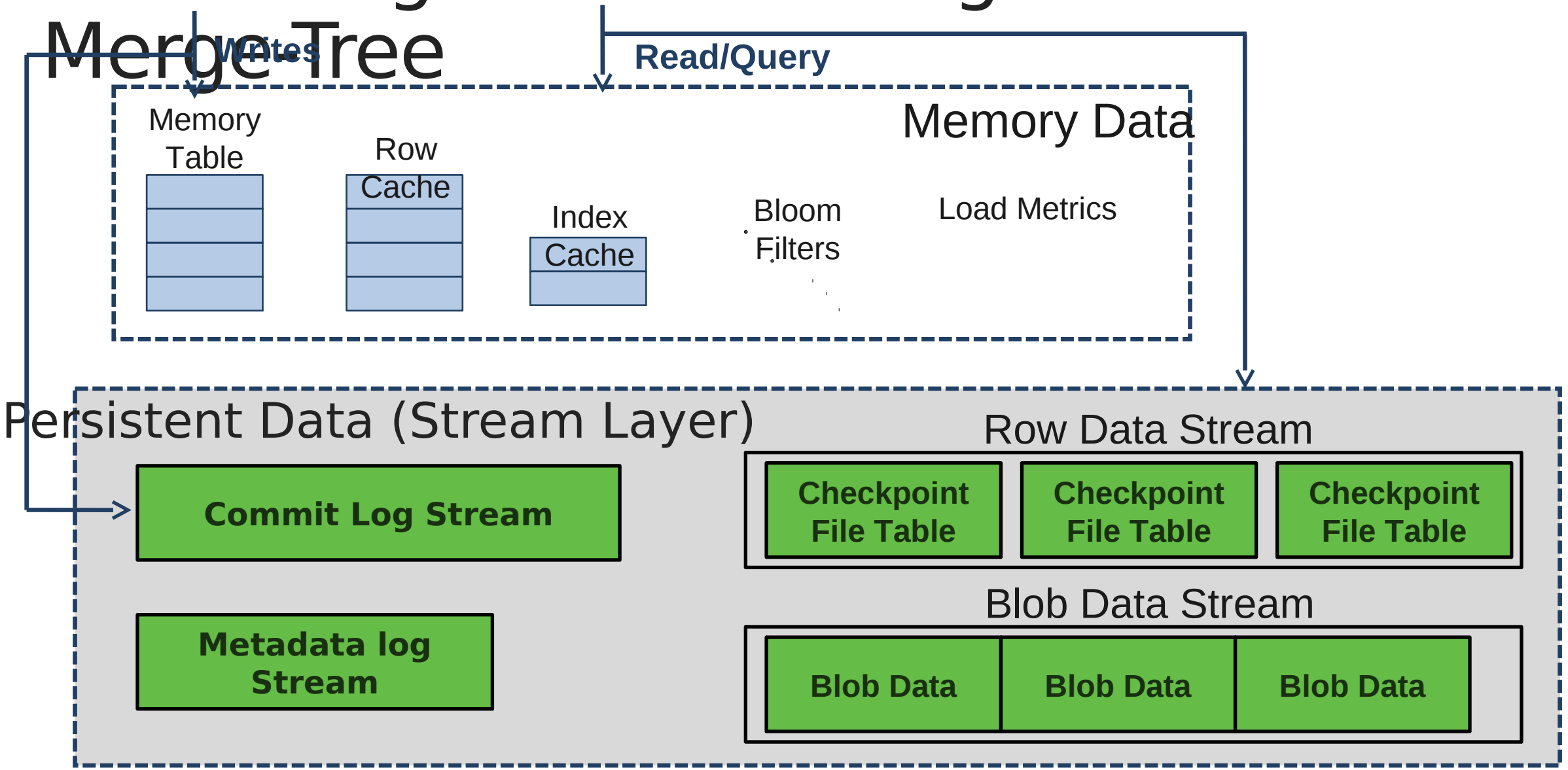
Partition Layer Data Model

- Provides internal data structure called Object Table
  - Account Table: stores metadata and configuration for each storage account assigned to the stamp
  - Blob Table: contains all blob objects for all accounts in a stamp
  - Entity Table: stores entity rows for all accounts in a stamp
  - Message Table: stores all messages for all accounts in a stamp
  - Partition Map Table: keeps track of the current RangePartitions
- Object tables are dynamically broken up into RangePartitions

Partition Layer Architecture



Each RangePartition – Log Structured Merge Tree



RangePartition Load Balancing

- The Partition Manager performs three operations to spread load across partition servers and control the total number of partitions in a stamp:
  - Load Balance
  - Split
  - Merge
- Based on:
  - Transactions/second
  - CPU usage
  - Network usage
  - Request latency
  - Data size of RangePartition

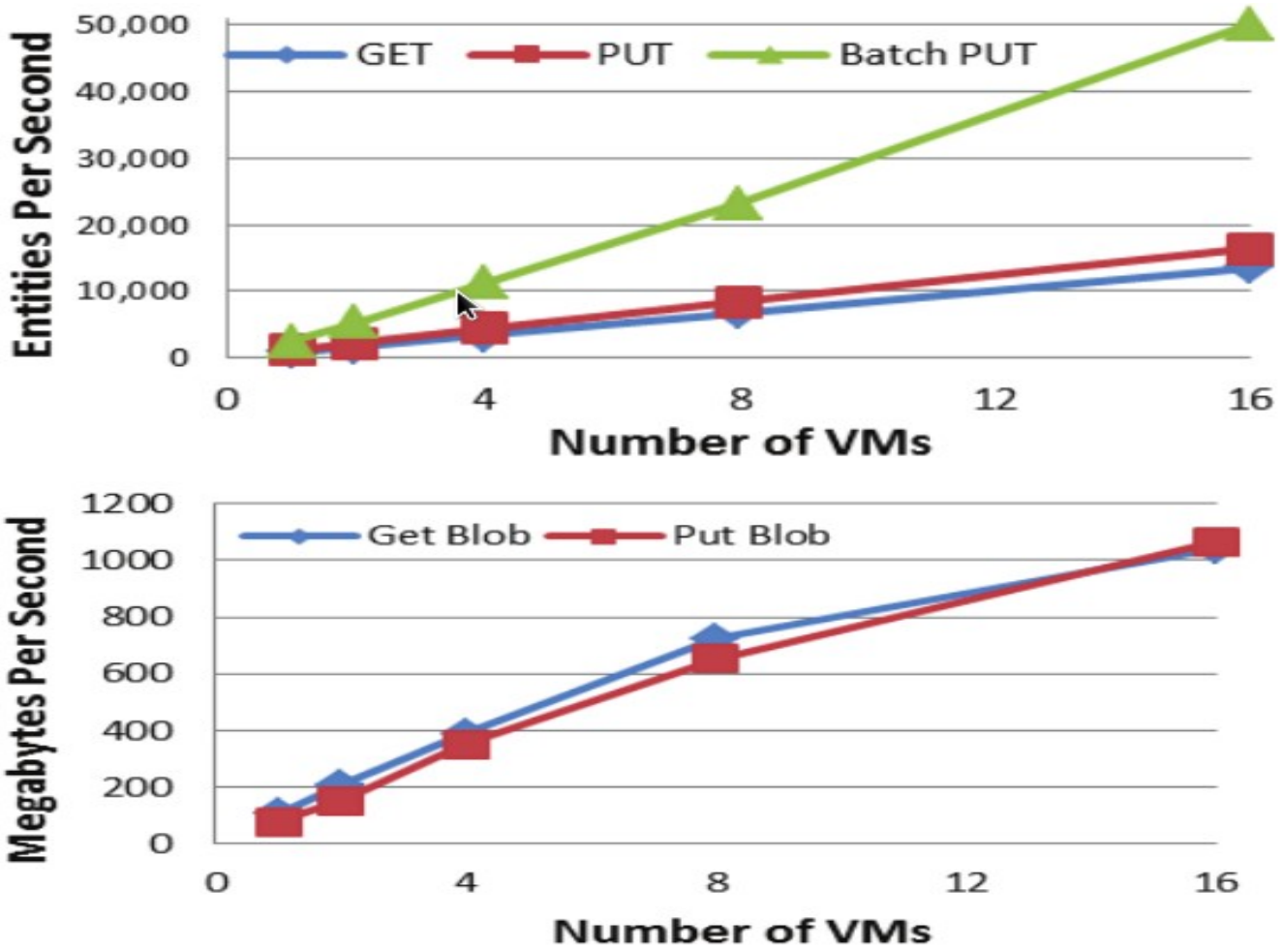
Inter-Stamp Replication

- An account has primary stamp and one or more secondary stamps
- Inter-Stamp replication is done asynchronoulsy
- Disaster recovery and account migration

Application Throughput

- Customers run their applications as a service on VMs.
- Seperate computation and storage into their own stamp
- Examine the performance of a customer application is running from their hosted service VM in the same data center as where their account data is stored

Application Throughput



Workload Profiles

Table 1: Usage Comparison for (Blob/Table/Queue)

		%Requests	%Capacity	%Ingress	%Egress
All	Blob	17.9	70.31	48.28	66.17
	Table	46.88	29.68	49.61	33.07
	Queue	35.22	0.01	2.11	0.76
Bing	Blob	0.46	60.45	16.73	29.11
	Table	98.48	39.55	83.14	70.79
	Queue	1.06	0	0.13	0.1
XBox GameSaves	Blob	99.68	99.99	99.84	99.88
	Table	0.32	0.01	0.16	0.12
	Queue	0	0	0	0
XBox Telemetry	Blob	26.78	19.57	50.25	11.26
	Table	44.98	80.43	49.25	88.29
	Queue	28.24	0	0.5	0.45
Zune	Blob	94.64	99.9	98.22	96.21
	Table	5.36	0.1	1.78	3.79
	Queue	0	0	0	0

Thank you!
Any questions?