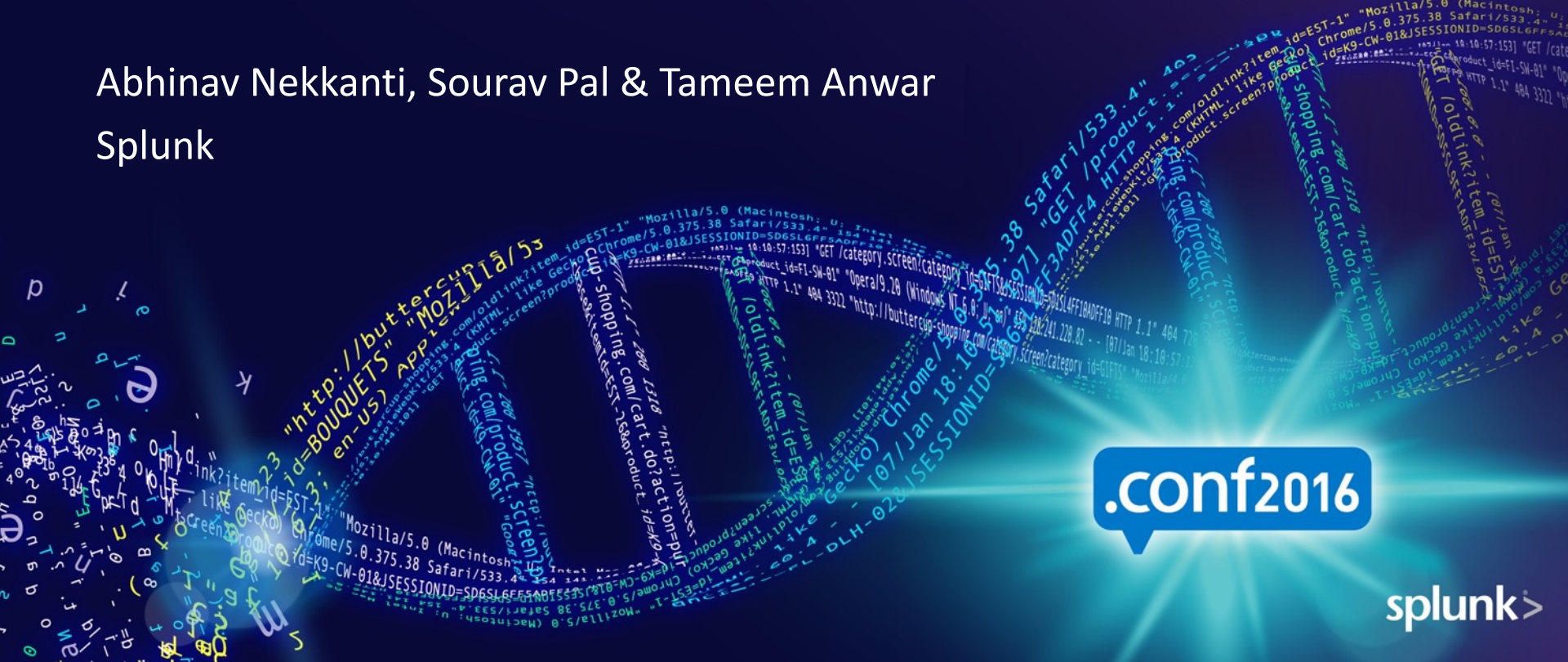
Harnessing Performance and Scalability with Parallelization

Abhinav Nekkanti, Sourav Pal & Tameem Anwar

Splunk



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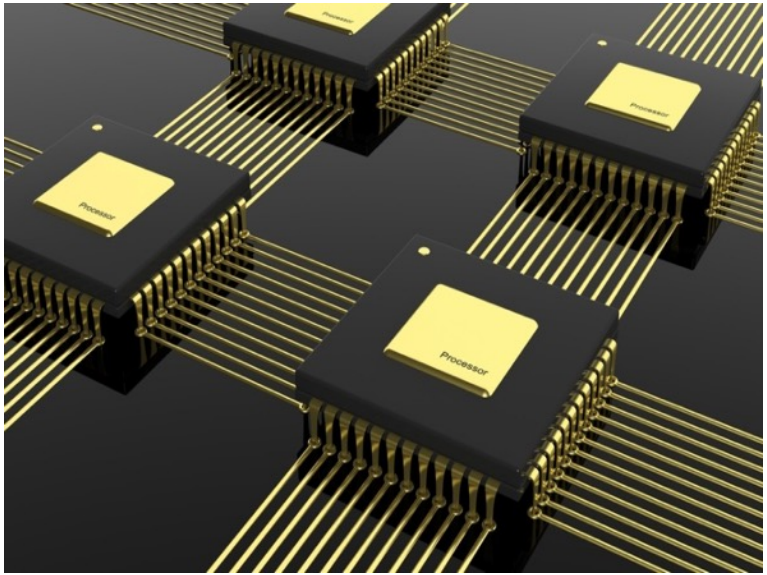
Agenda

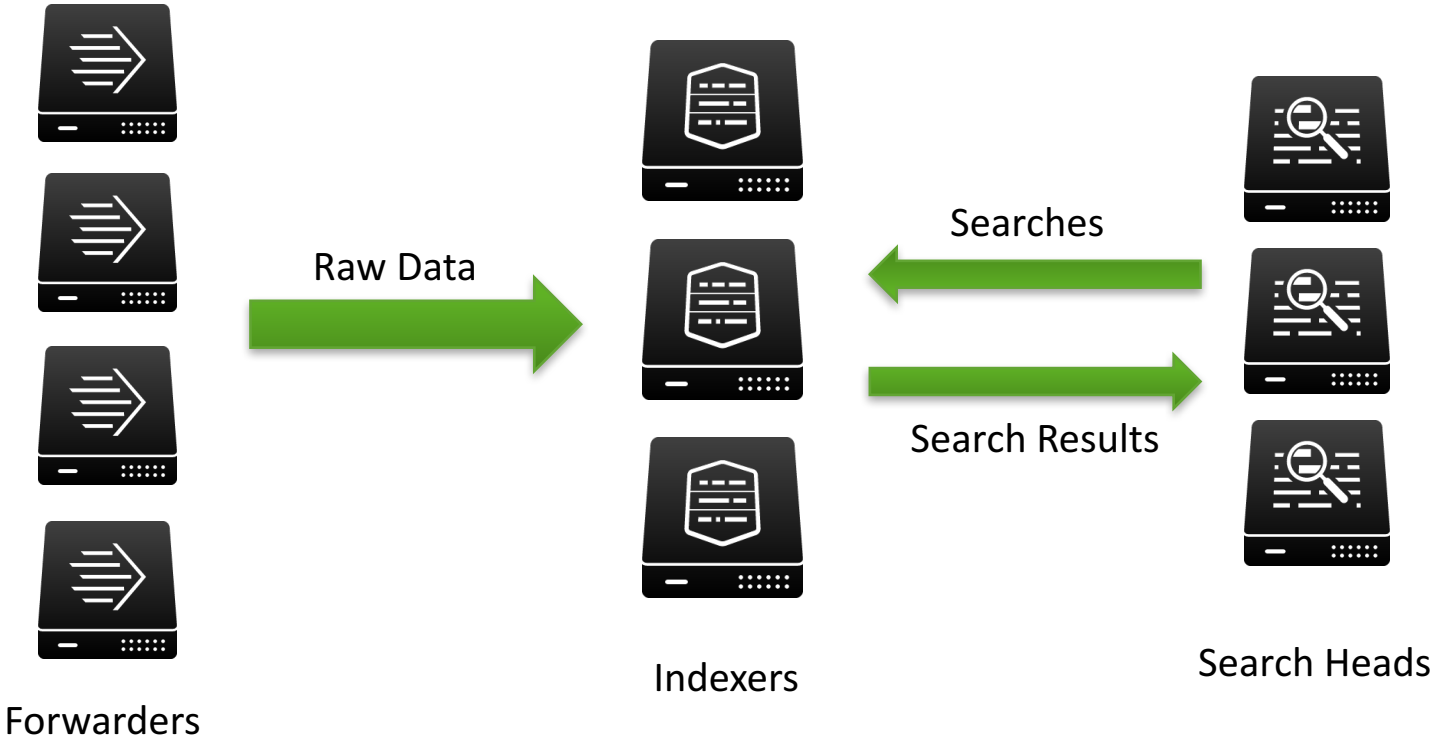
- Under-utilized hardware?
- Multiple ingestion pipelines
- Parallelizing search
- Performance
- Best practices



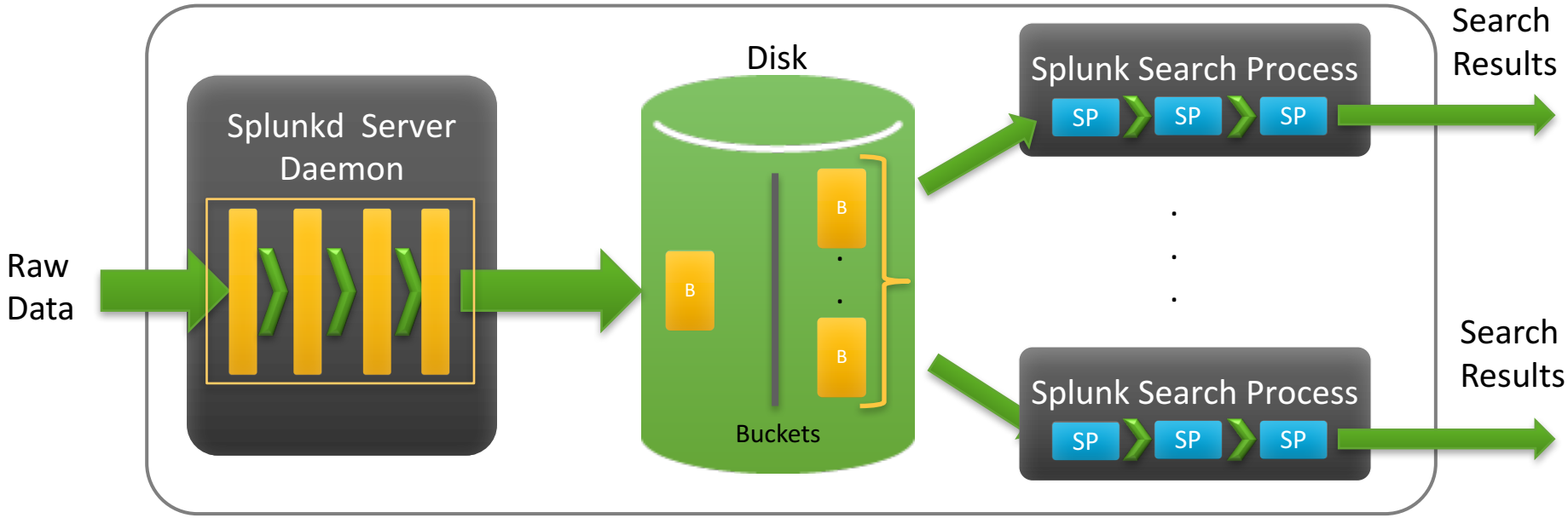
About Us

- Abhinav Nekkanti - Sr. Software Engineer, Splunk
  - Ingestion Pipeline
- Sourav Pal - Principal Engineer, Splunk
  - Search Parallelization
- Tameem Anwar - Software Engineer, Splunk
  - Performance

3 Tier Architecture

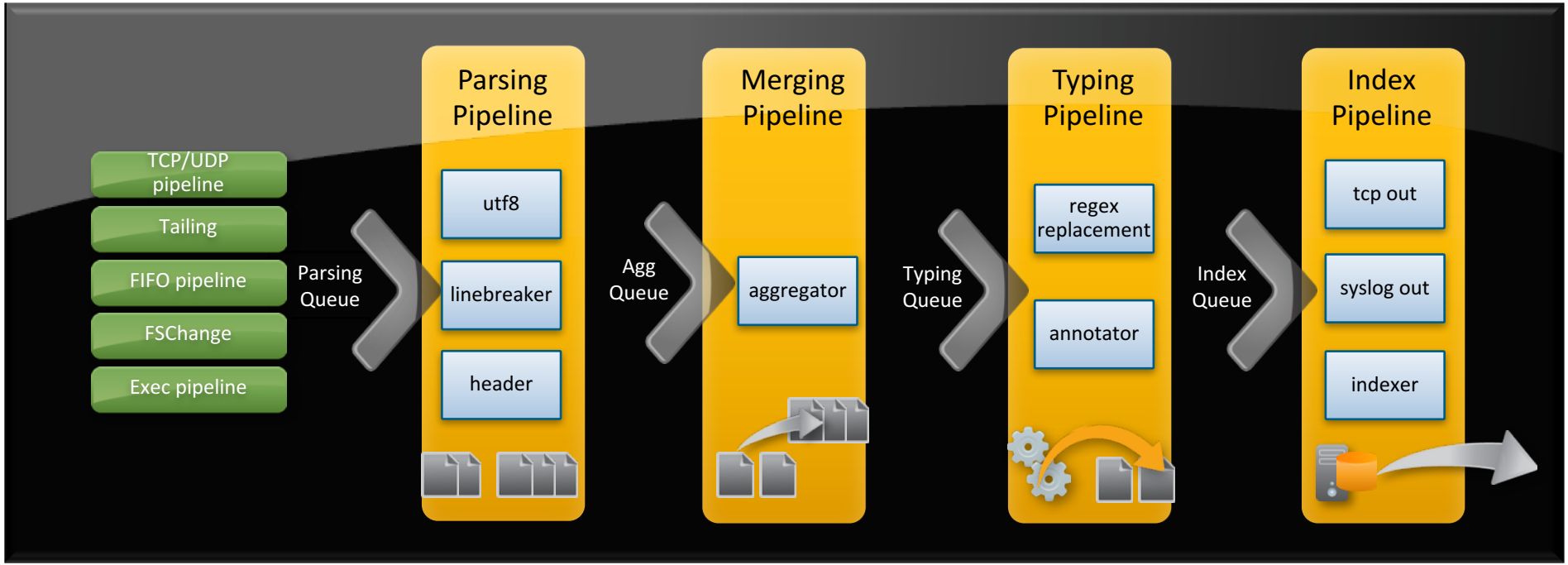


Insight into the Indexer



Traditional Indexer Hosts

Splunkd Server Daemon / Pipelineset



Ingestion Pipeline Set

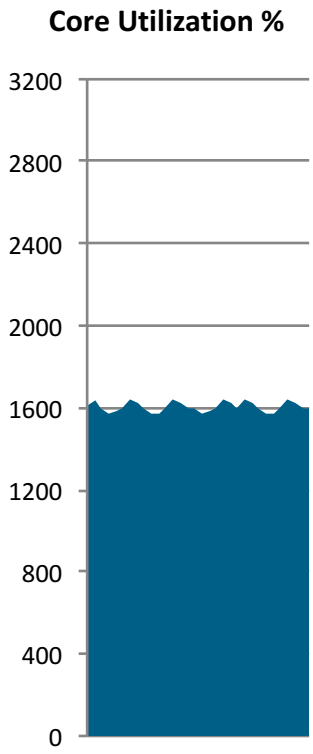
Indexer Core Utilization

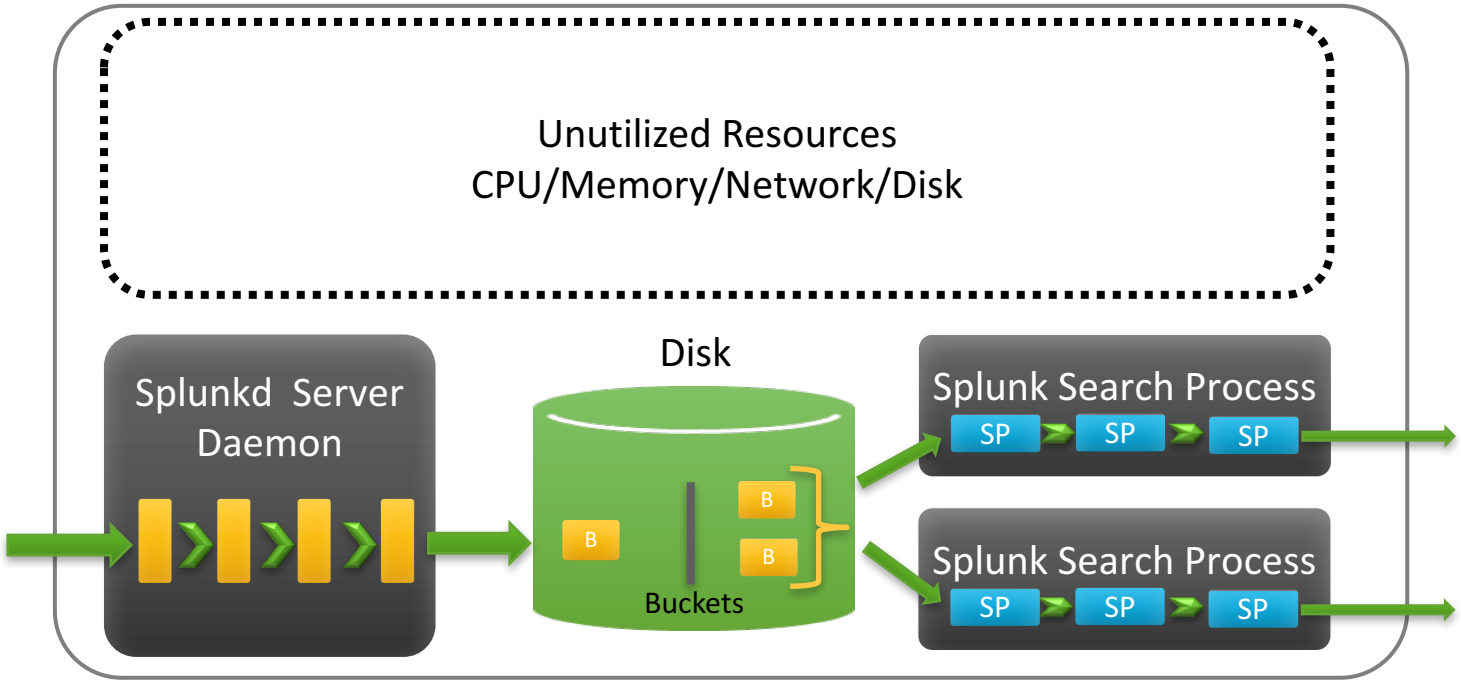
- Rule of Thumb:

Process	Cores (approx.)
Splunkd Server Daemon	4 to 6 cores
Splunk Search Process	1 core / search process

- Example core utilization of a Indexer Host:
  - 4 to 6 cores for Splunkd Server daemon
  - 10 X 1 cores for Splunk Search Processes
  - Total cores used: 14 to 16 cores

Under-utilized Indexer



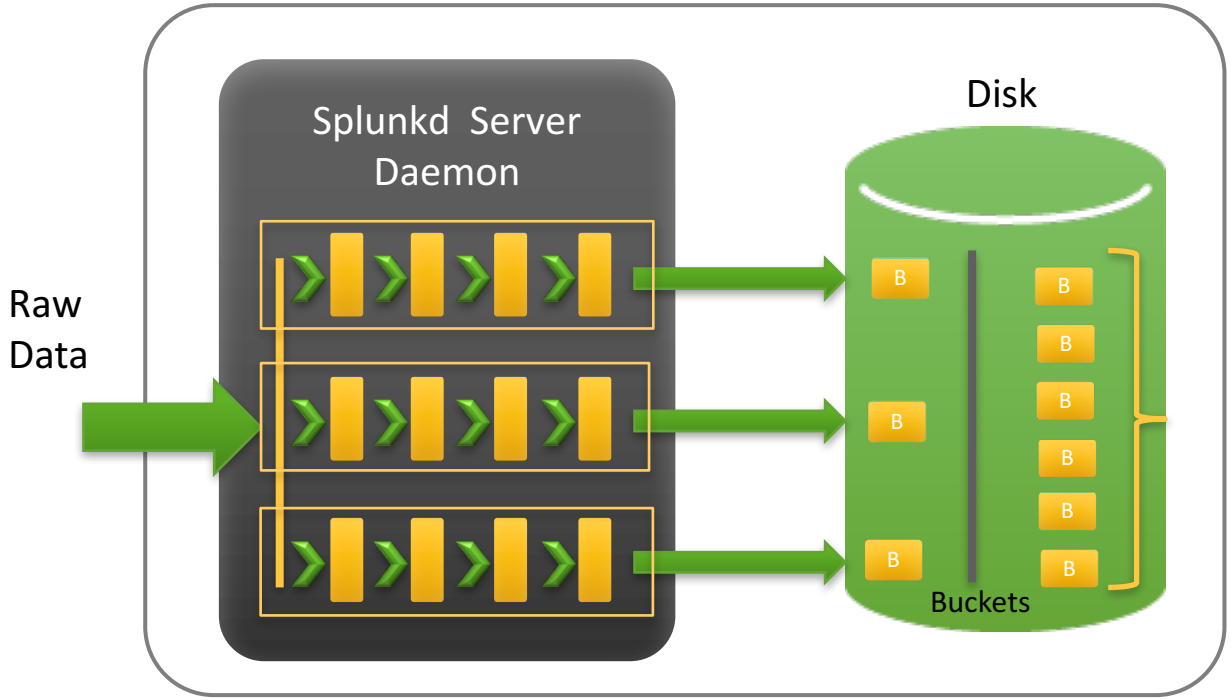


Performance Enhancements

- Multiple Pipeline Sets
  - Parallel ingesting pipeline sets
  - Improves resource utilization of the host machine
- Search Improvements
  - Faster batch searches using parallel search pipelines
  - Scheduler improvements
  - Faster Summary buildup

Multiple Ingestion Pipeline Sets

Splunkd with Multiple Ingestion Pipeline Sets



Indexer with 3 Pipeline Sets

Configuring Multiple Ingestion Pipeline Sets

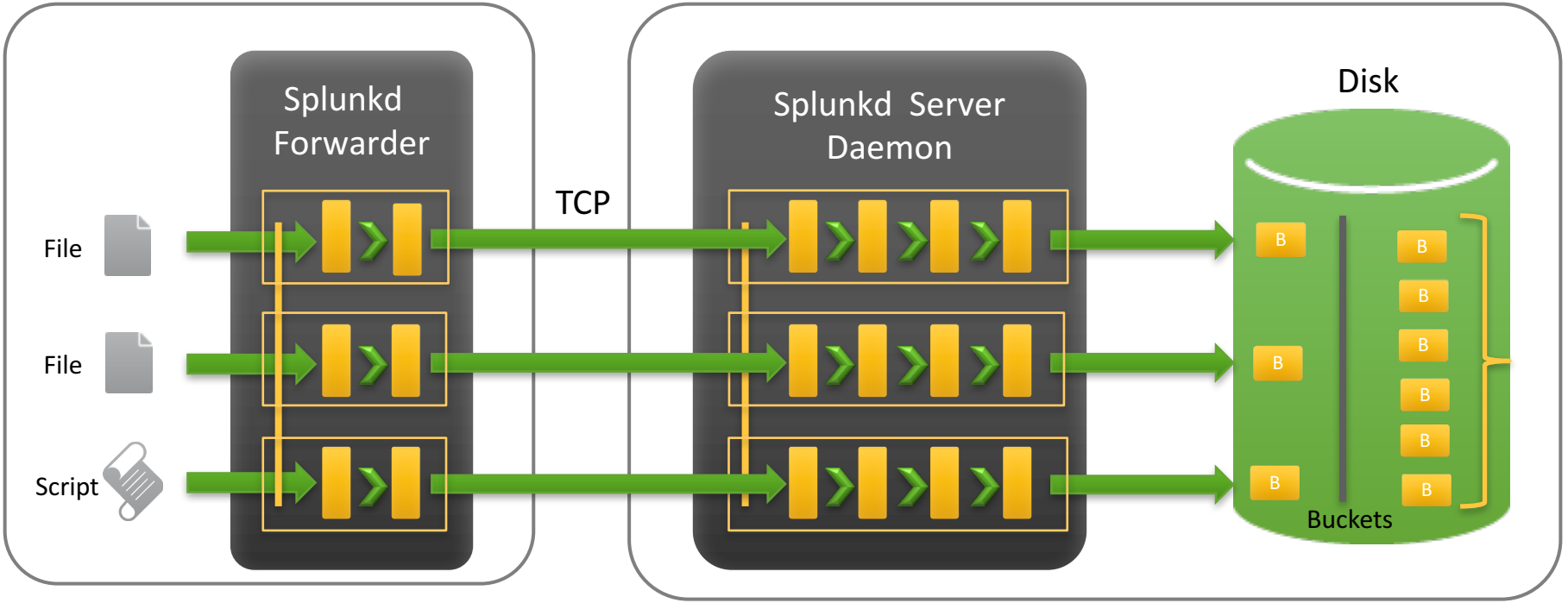
- $SPLUNK_HOME/etc/system/local/server.conf

```
[general]
parallelIngestionPipelines = 2
```

Multiple Ingestion Pipeline Sets – Details

- Each Pipeline Set has its own set of Queues, Pipelines and Processors
  - Exceptions are Input Pipelines which are usually singleton
- No state is shared across Pipeline Sets
- Data from a unique source is handled by only one Pipeline Set at a time

Multiple Ingestion Pipeline Sets over Network



Forwarder with 3 Pipeline Sets

Indexer with 3 Pipeline Sets

Multiple Ingestion Pipeline Sets – Monitor Input

- Each Pipelineset has its own set of TailReader, BatchReader and Archive Processor
- Enables parallel reading of files and archives on Forwarders
- Each file/archive is assigned to one pipeline set

Multiple Ingestion Pipeline Sets - Forwarding

- Forwarder:
  - One tcp output processor per pipeline set
  - Multiple tcp connections from the forwarder to different indexers at the same time
  - Load balancing rules applied to each pipeline set independently
- Indexer:
  - Every incoming tcp forwarder connection is bound to one pipeline set on the Indexer

Multiple Ingestion Pipeline Sets - Indexing

- Every pipeline set will independently write new data to indexes
- Data is written in parallel to better utilize resources
- Buckets produced by different pipeline sets could have overlapping time ranges

Search :
Parallelization Efforts
Performance Improvements

Search Parallelization: Performance Improvement

Splunk Searches are faster.

- Parallelizing the Search Pipeline
- Improving the Search Scheduler
- The Summary Building is parallelized and faster.

Search Pipeline

Batch Search

Reading Order

Reading Order

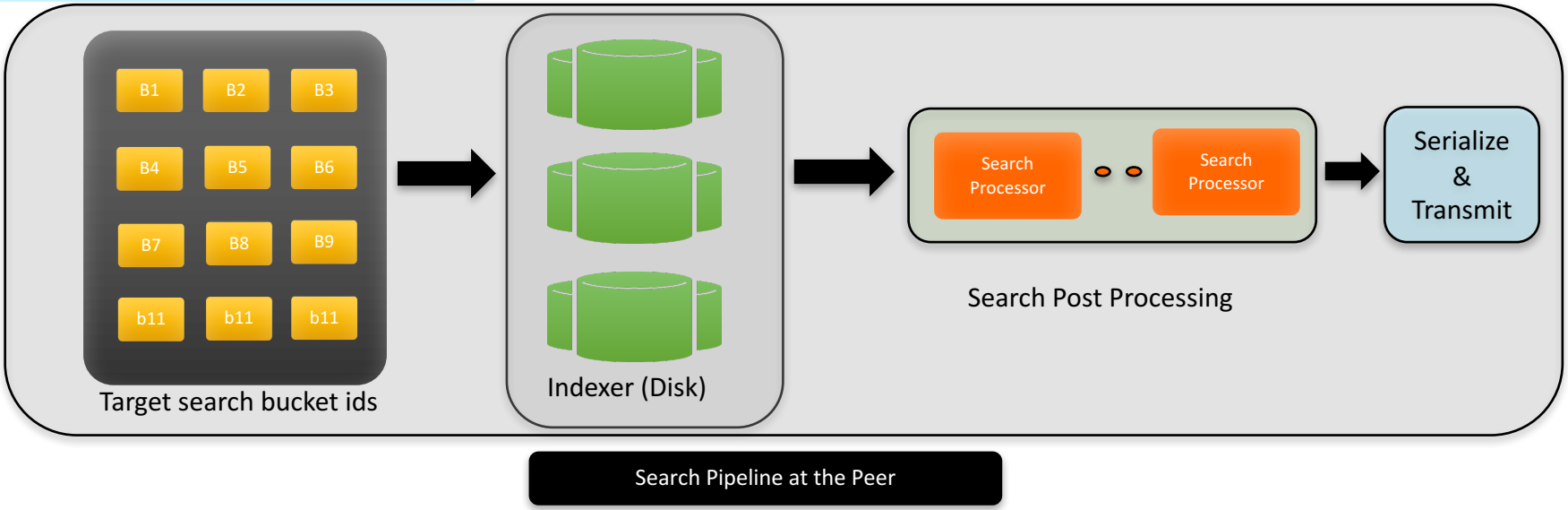
Option1:…B3 B5 B1 B2 B1 B6

Option2:…B6 B5 B4 B3 B2 B1

Option 3…B6 B5 B4 B7 B4 B9

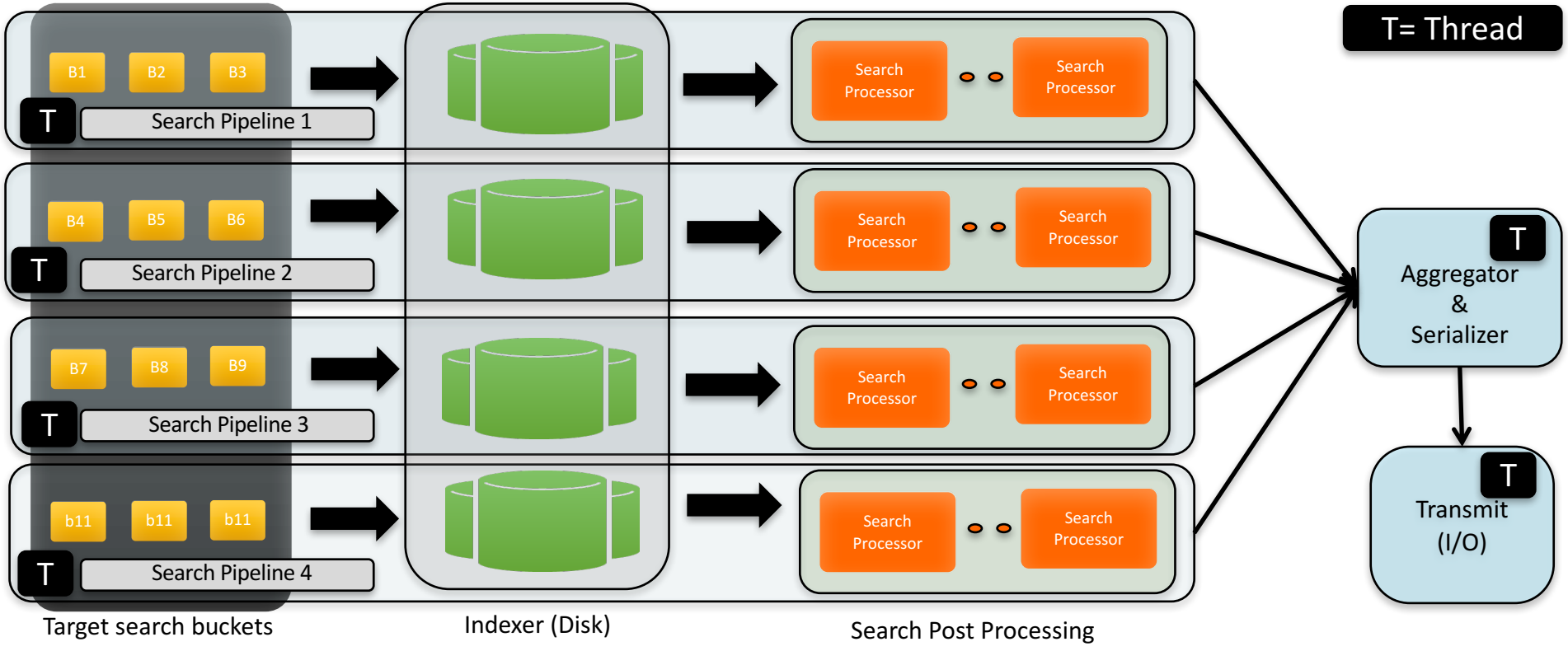
- Cursored Search: Time ordered data retrieval
- Batch Search: Bucket ordered data retrieval

Facilitates parallel processing of buckets independently across multiple pipeline



Search Pipeline at the Peer

Batch Search: Pipeline Parallelization



Batch Search: Pipeline Parallelization

- Under-utilized indexers provide us opportunity to execute multiple search pipelines.
- Batch Search time-unordered data access mode is ideal for multiple search pipelines.
- No state is shared i.e. no dependency exists across Search Pipelines.
- Peer/Indexer side optimizations.
- Takeaway :
  - Under utilized indexers are candidates for search pipeline parallelization.
  - Do NOT enable if indexers are loaded.

Configuring the Batch Search in Parallel mode

- How to enable?

  $SPLUNK_HOME/etc/system/local/limits.conf

```
[search]
batch_search_max_pipeline  = 2
```

- What to expect?

  Search performance in terms of retrieving search results improved.

  Increase in number of threads

Search Scheduler Improvements

- Scheduler improvements in Splunk Enterprise:
  - Priority Scoring
  - Schedule Windows
- Performance improvements over previous schedulers
  - Lower Lag
  - Fewer skipped searches

Search Scheduler Improvements
Priority Score

Problem:

Simple single-term priority scoring could result in saved search lag, skipping, and starvation (under CPU constraint).

Solution:

Better multi-term priority scoring mitigates problems and improves performance by 25%.

```
score(j)    = next_runtime(j)
            + average_runtime(j) ×
priority_runtime_factor
            – skipped_count(j) × period(j) ×
              priority_skipped_factor
            + schedule_window_adjustment(j)
```

Search Scheduler Improvements

Problem :

Scheduler can not distinguish between searches that (A) *really should* run at a specific time (just like cron) from those that (B) don't have to. This can cause lag or skipping.

Solution :

Give a *schedule window* to searches that don’t have to run at specific times.

Example:

For a given search, it’s OK if it starts running sometime between midnight and 6am, but you don't really care when specifically.

- A search with a window helps *other* searches.
- Search windows *should not* be used for searches that run every minute.
- Search windows *must* be less than a search’s period

Configuring Search Scheduler

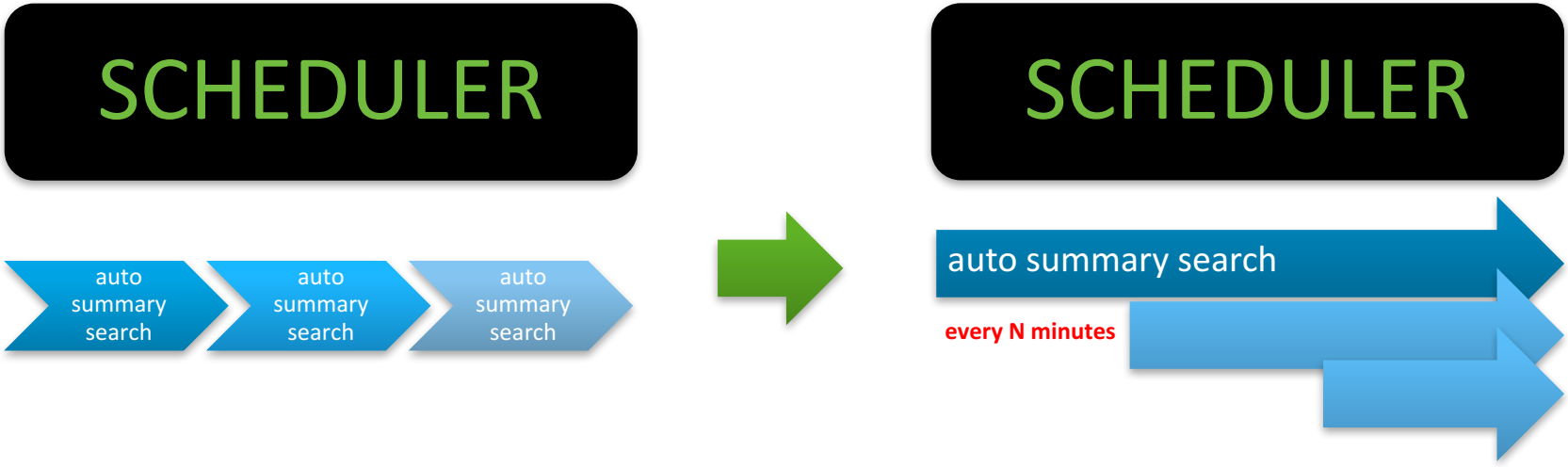
$SPLUNK_HOME/etc/system/local/limits.conf

```
[scheduler]
max_searches_perc = 50

# Allow value to be 75 anytime on weekends.
max_searches_perc.1 = 75
max_searches_perc.1.when = * * * * 0,6

# Allow value to be 90 between midnight and 5am.
max_searches_perc.2 = 90
max_searches_perc.2.when = * 0-5 * * *
```

Search: Parallel Summarization

- Sequential nature of building summary data for data model and saved reports is slow.
- Summary Building process has been parallelized.

Summary Building Parallelization



Sequential Summary Building

Parallelized Summary Building

Configuring Summary Building for Parallelization

- $SPLUNK_HOME/etc/system/local/savedsearches.conf

```
[default]
auto_summarize.max_concurrent = 1
```

- $SPLUNK_HOME/etc/system/local/datamodels.conf

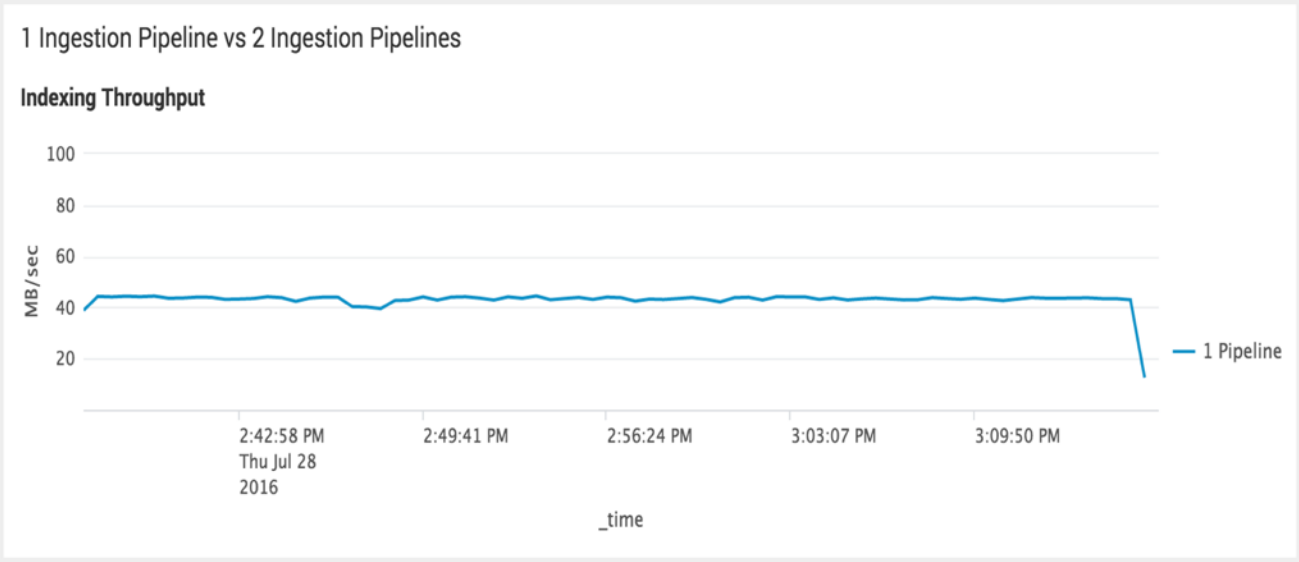
```
[default]
acceleration.max_concurrent = 2
```

Performance

Performance Tests

- System Info
  - 2x12 Xeon 2.30 GHz
  - 24 cores (48 w/HT)
  - 64 GB RAM
  - 8 x 300GB 15k RPM disks in RAID-0
  - 1 Gb Ethernet NIC
  - CentOS 7.6
- No other load on the box

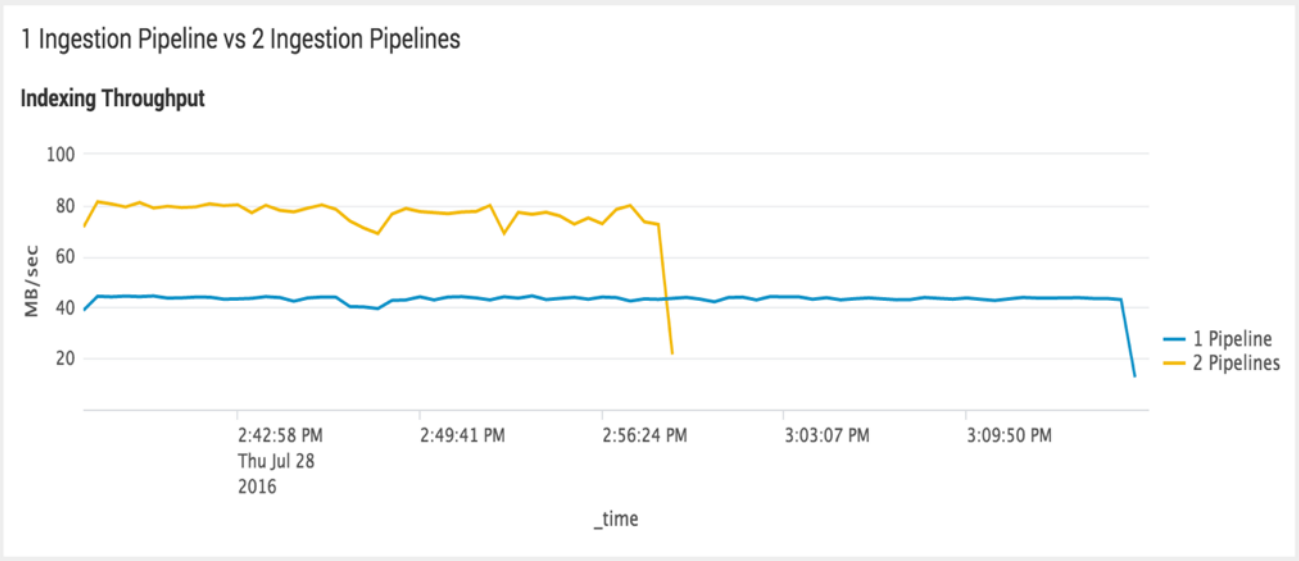
Indexing



Pipelines	Time taken (minutes)
1	40.25 m
2	

- Index a 100 GB generic syslog dataset. No search loads.
- Average Indexing Throughput – 41.40 MB/s

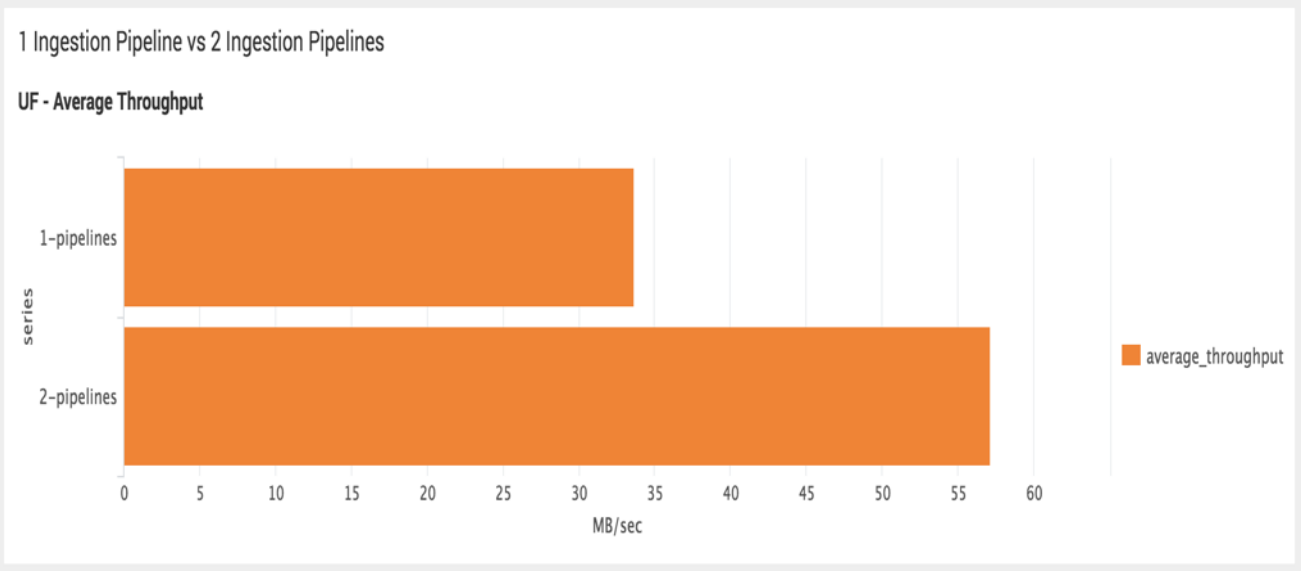
Indexing



Pipelines	Time taken (minutes)
1	40.25 m
2	21.16 m

- Average Indexing Throughput – 78.80 MB/s
- 90 % Increase in Average Indexing Throughput
- On an average Splunk utilized 2x CPU cores , 1.3x Memory and 2x Disk IOPS

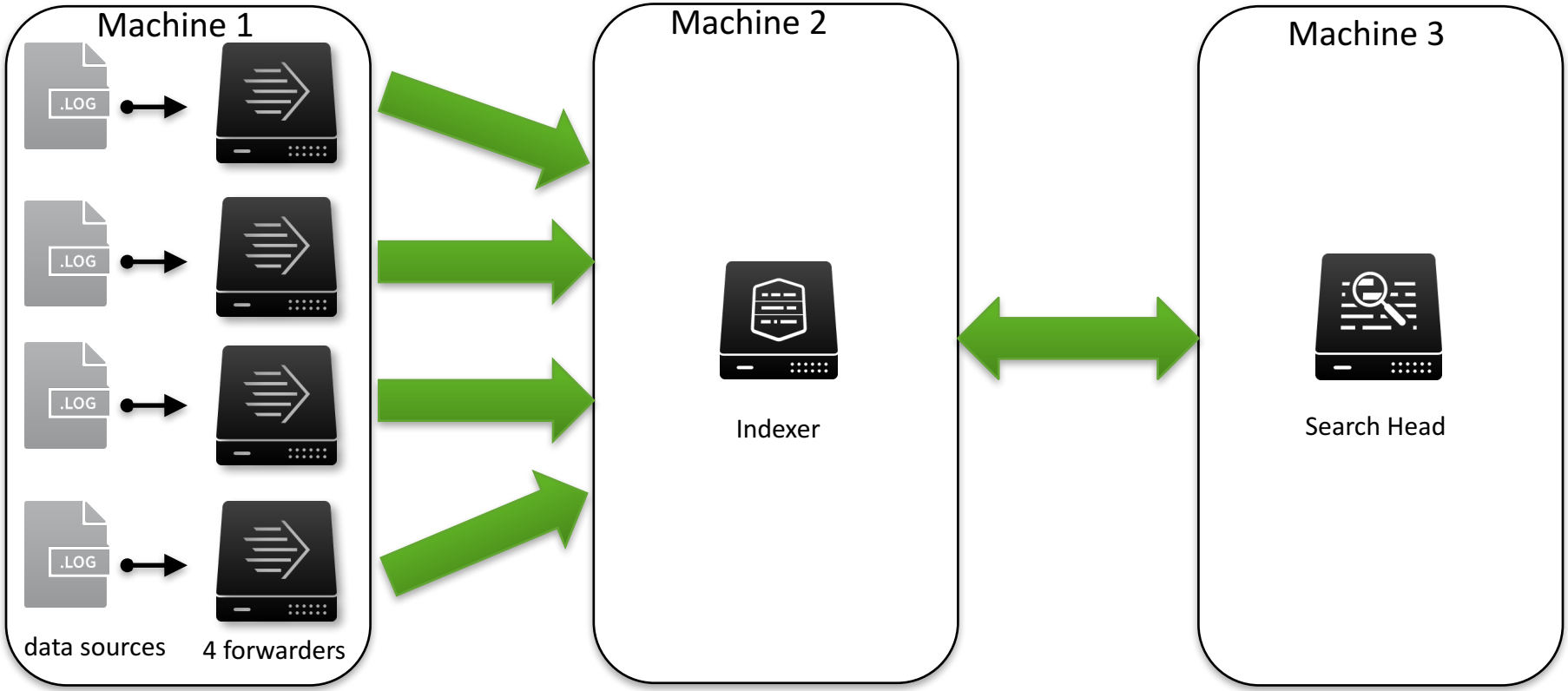
Forwarding



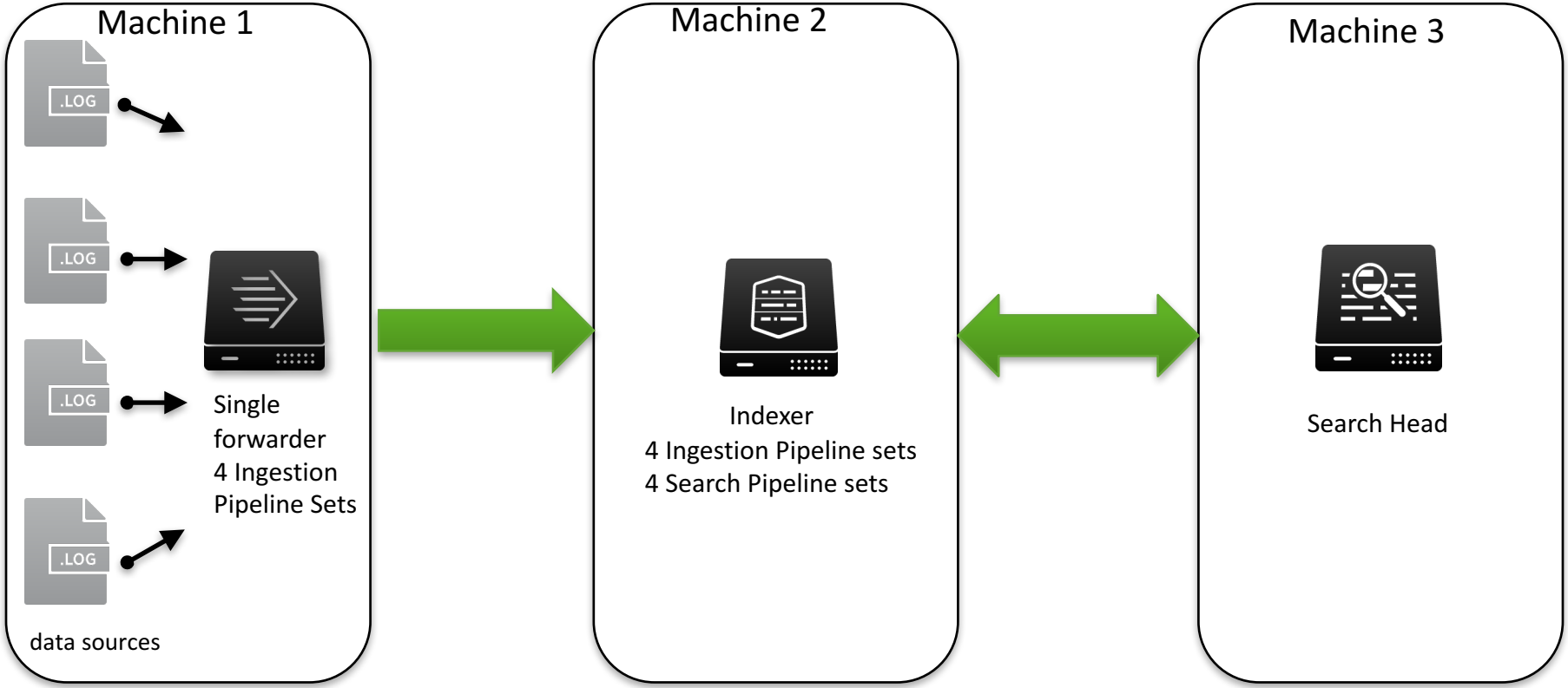
Pipelines	Average Throughput
1	33.6 MB/s
2	57.1 MB/s

- UF sending 100 GB syslog dataset (1k files)
- 70 % Increase in Average Throughput
- On an average Splunk utilized 2x the resources

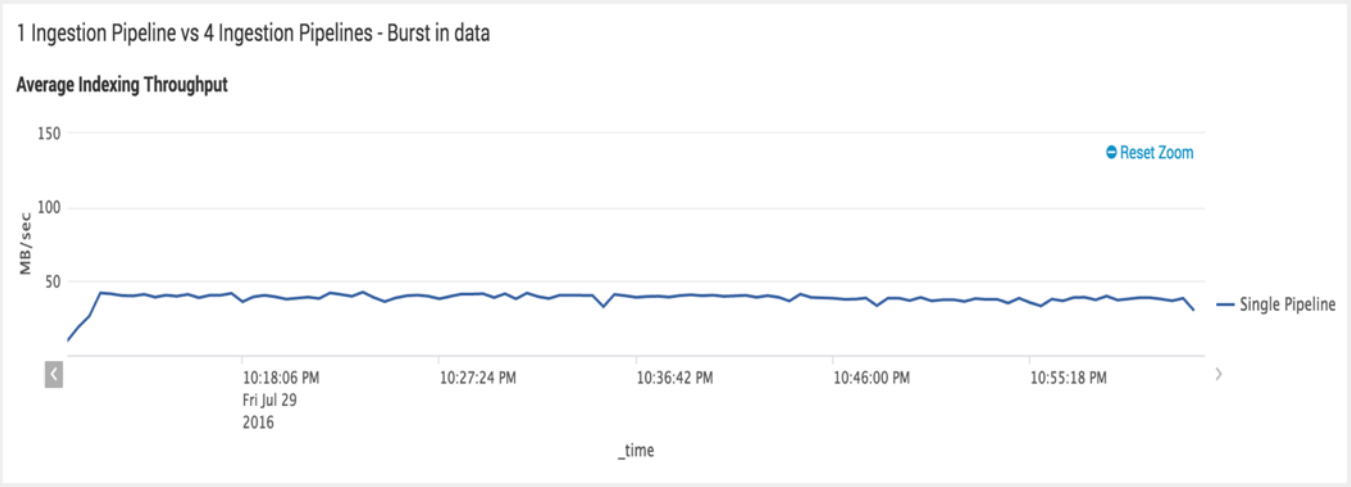
Splunk without Parallelization



Splunk with Parallelization



Burst in Indexing Load + Searches

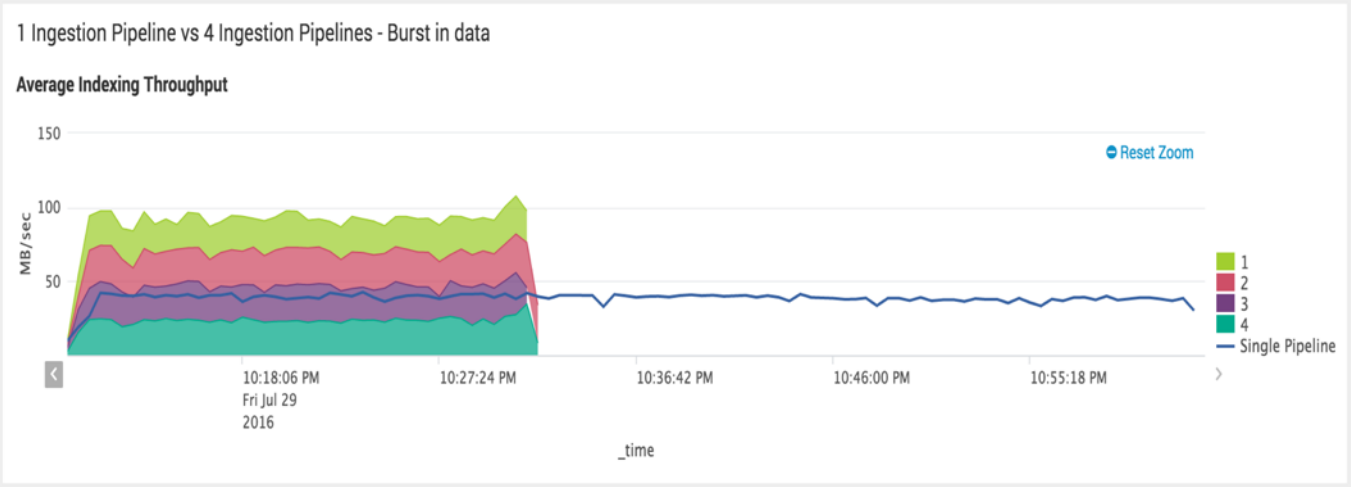


Ingestion Pipelines	Time (mins)
1	53 m
4	

Splunk without Parallelization

- Data forwarded @ 10 MB/s + Monitor 100 GB dataset
- Average Indexing Throughput – 39.12 MB/s
- Number of Concurrent Searches – 4

Burst in Indexing Load + Searches

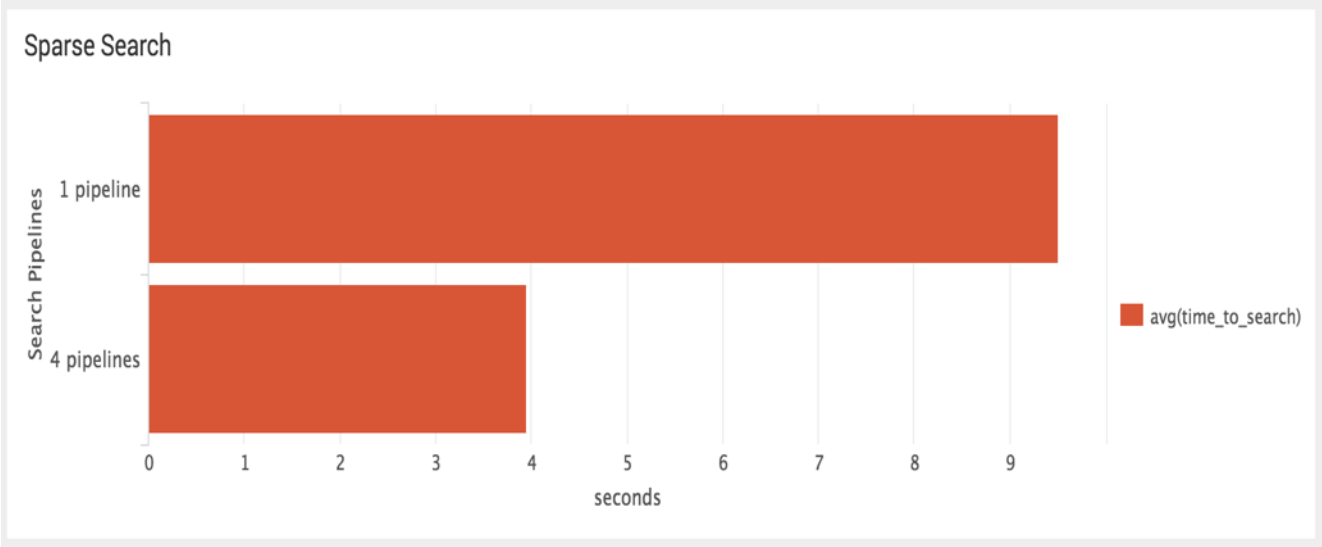


Ingestion Pipelines	Time (mins)
1	53 m
4	22.5 m

Splunk with Parallelization

- Data forwarded @ 10 MB/s + Monitor 100 GB dataset
- Average Indexing Throughput – 94.7 MB/s
- 142% Increase in Average Indexing Throughput
- Number of Concurrent Searches – 4

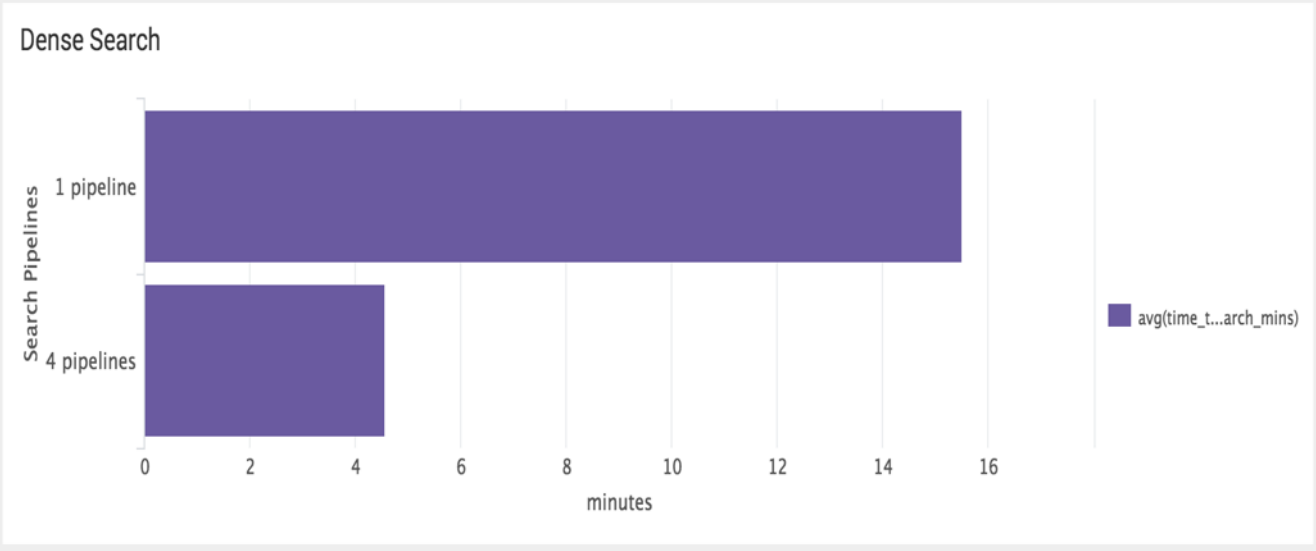
Batch Mode Sparse Search



Search Pipelines	Time (seconds)
1	9.51 s
4	3.90 s

- Sparse Search – Characterized predominately by returning some events per bucket
- 1 Search Pipeline vs 4 Search Pipelines
- Search is 2.4x faster with Search Parallelization

Batch Mode Dense Search



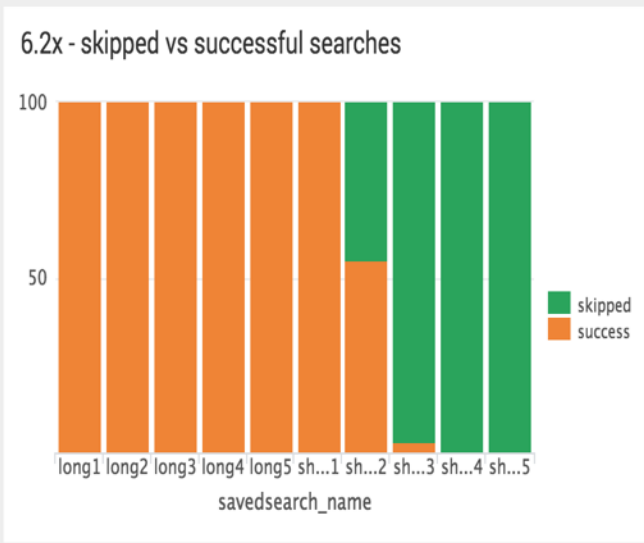
Search Pipelines	Time (minutes)
1	15.5 m
4	4.57 m

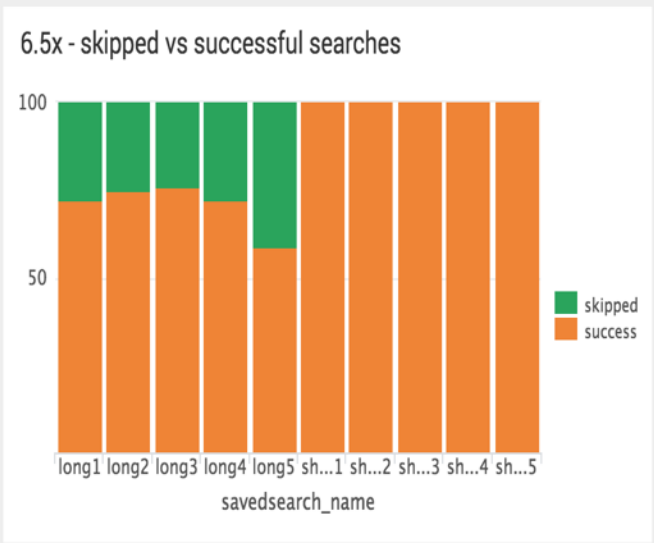
- Dense Search – Characterized predominately by returning many events per bucket
- 1 Search Pipelines vs 4 Search Pipelines
- Search is 3.4x faster with Search Parallelization

Scheduled Searches Setup

- 10 searches are scheduled to run every minute
- 5 longer running searches (~40s)
- 5 shorter running searches (~15s)
- Test configured to run only 3 scheduled concurrently

Scheduled Searches

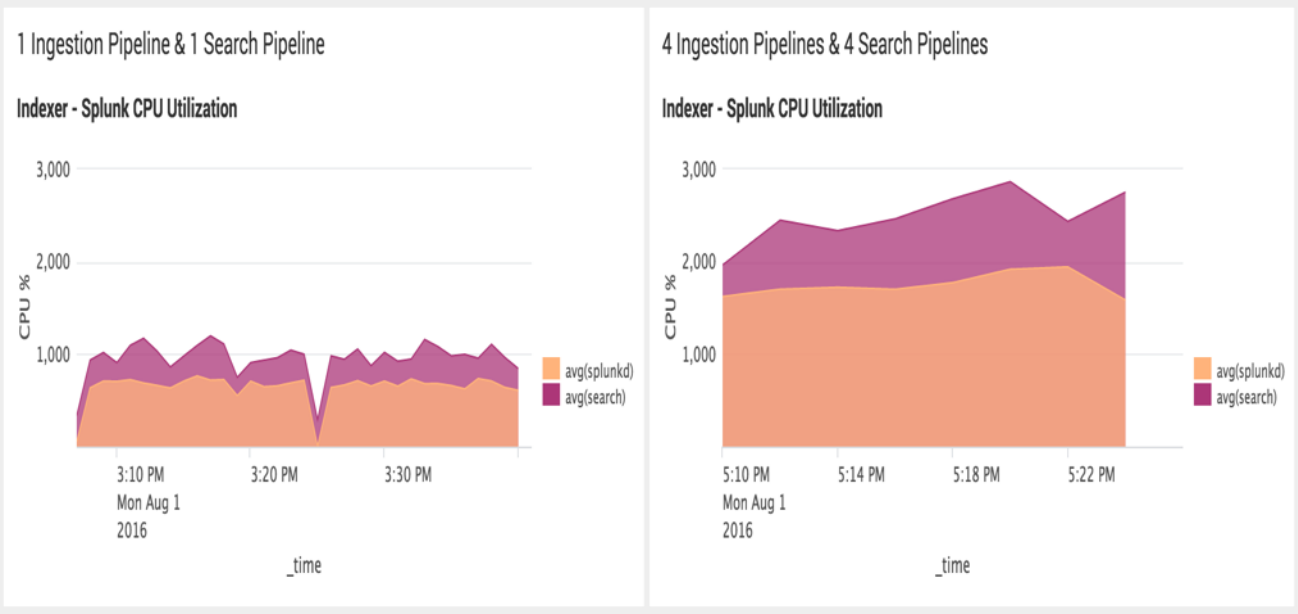




Version	Searches completed
6.2	191
6.5	248

- Skipped vs. Successful Searches – 30 minute window
- 30% Increase in Successful Searches
- This optimization will not utilize additional System Resource

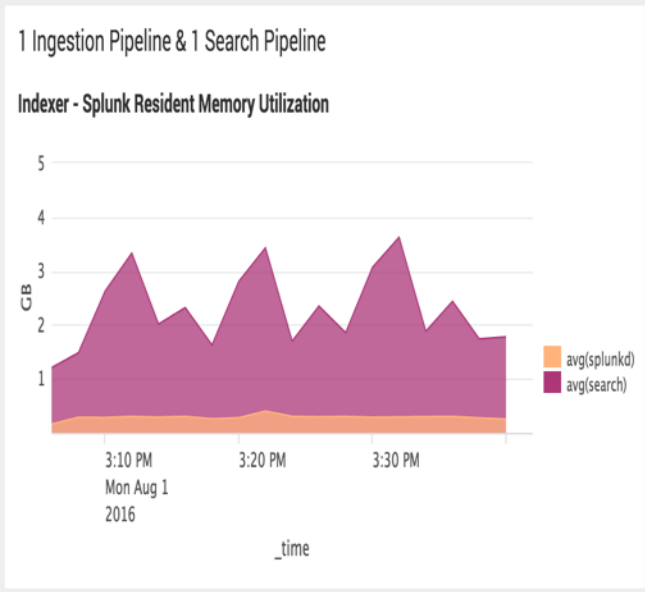
CPU Utilization

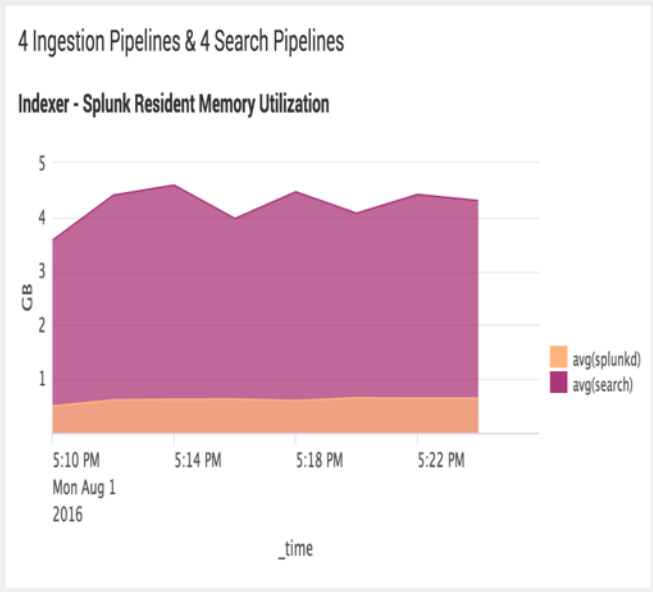


Ingestion Pipelines	Search Pipelines	CPU Utilized
1	1	990 %
4	4	2437 %

- Burst in Indexing Load + Searches
- CPU utilized by splunkd & search process

Memory Utilization

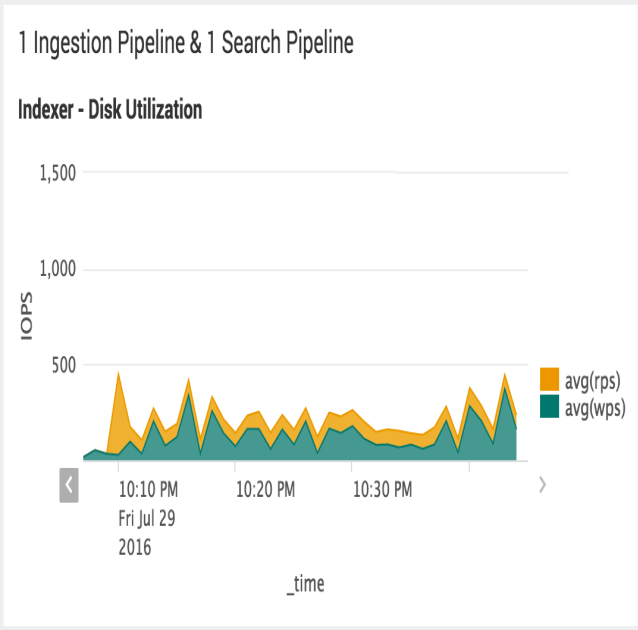


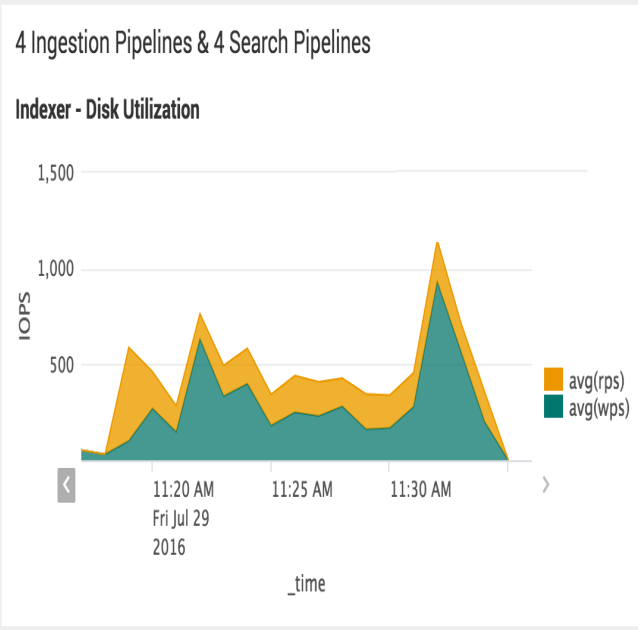


Ingestion Pipelines	Search Pipelines	Memory Utilized
1	1	3.32 GB
4	4	4.59 GB

- Burst in Indexing Load + Searches
- Resident Memory utilized by splunkd & search process

Disk I/O





Ingestion Pipelines	Search Pipelines	Average Disk IOPS
1	1	202
4	4	579

- Burst in Indexing Load + Searches
- Average Read and Writes Operations per second

Final Thoughts

- What is my Current Workload?
  - Data volume – Daily and Peak
  - Search Volume – Concurrent and total
  - System Resource Usage
- How do I approach these features?
  - System significantly under-utilized ?
  - Search Pipelines
    - Lot of Batch mode Searches ?
  - Parallel Ingestion Pipelines
    - Handling Bursts in Data?
    - Reading large number of files in parallel?
- Don’t forget about Horizontal scaling

THANK YOU

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