Optimizing Splunk Knowledge Objects
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Why are we here?

New Search

tag=authentication tag=failure

Parsing job...
Why are we here?

“Oversized litsearch is the largest performance problem we face in our environment.”

- Jacob Wilkins, General Electric
Why are we here?

- Observed search run time progression during development
- Massive growth in job startup time
- Knowledge Object optimization reduced that overhead by 80%
Who’s that guy?

- Professional Services Consultant, Certified Architect, Splunk-It-All
- Five years at EMEA Splunk Partner
- Heavy Splunker since 2012

- Get in touch with me: martin.mueller@consist.de
- Give karma at Splunk Answers: martin_mueller
- Hang in #splunk on Efnet: martin_m
Session Objectives

- Understand how Splunk turns a search into results
- Learn how to recognize if you have a problem (Spoiler Alert: You do!)
- Use this to your advantage when specifying search-time knowledge

Covered knowledge objects:
- Fields
- Reverse Lookups
- Eventtypes
- Tags
Let’s dive in...
...but first, to the Job Inspector!

- **normalizedSearch**: Ultra-verbose stage of search assembly

```
normalizedSearch
litsearch index=_audit ( action=search OR ( sourcetype=audittrail ) ) |
litsearch index=_audit action=search | fields keepcolorder=t "*" "_bkt" "_cd" "_si" "host" "index" "linecount" "source" "sourcetype" "splunk_server"
```

- Performance stats, e.g. time spent assembling the normalizedSearch

```
15.91 dispatch.createdSearchResultInfrastructure
```

- Links to search.log to look for more hidden performance hogs

Calculated Fields (1)

- TA-splunk, props.conf: `[audittrail]`  
  EVAL-action=case(condN, valN, 1=1, action)
- Splunk’s assumption about looking for indexed tokens doesn’t hold
- No way to translate the eval expression into tokens
- Plain Search: `index=_audit  action=search`  
  `normalizedSearch: index=_audit  (action=search  
   OR (sourcetype=audittrail))`
- Load all events for that stanza plus events with the token, filter later
Calculated Fields (2)

- What if you’re not searching for that sourcetype?

  ```
  index=_internal sourcetype=splunk*
  action=logout
  index=_internal sourcetype="splunk*"
  (action=logout OR (sourcetype=audittrail))
  ```

- Splunk expands each segment of your search on its own
- For each calculated field, add stanza to every search for that field
- This is only the beginning of normalizedSearch overhead!
Field Aliases

- Sourcetype A has field `username`, sourcetype B has field `uid`, ...
- Field aliases can normalize this to `user` over all sourcetypes
- `sourcetype=A user=martin` yields this normalized search:
  `sourcetype=A ((sourcetype=A AND (username=martin)) OR (sourcetype=B AND (uid=martin)) OR (sourcetype=audittrail AND (uid=martin))) OR (user=martin)`
- All field aliases for all sourcetypes are used in all searches!
A real-world example

- Splunk App for Enterprise Security 3.3.1
- The TAs shipped define 19 field aliases for user
- Your environment will have additional TAs
- Watch your normalizedSearch strings and search startup time grow

- Let’s not forget the upside though: Without standardized field names, searching over different sourcetypes would be impossible
- Are you building a TA? Extract standardized field names directly!
A real-world example

- Searching for user=martin yields 2kB of normalizedSearch:

  (((sourcetype="*") AND ((username=martin))) OR ((sourcetype=A) AND ((username=martin))) OR ((sourcetype=B) AND ((uid=martin))) OR ((sourcetype="WMI:UserAccounts") AND ((Name=martin))) OR ((sourcetype="WinEventLog:Application:sophos") AND ((User=martin))) OR ((sourcetype="WinEventLog:SophosPatch") AND ((User=martin))) OR ((sourcetype="audittrail") AND ((uid=martin))) OR ((sourcetype="aws:cloudtrail") AND (("sourceIdentity.userName"="martin") OR "userIdentity.sessionContext.sessionIssuer.userName"="martin") OR "userIdentity.userPrincipalName"="martin") OR ((sourcetype="cef") AND ((suser="martin"))) OR ((sourcetype="cisco:sourcefire:appliance:syslog") AND ((User="martin"))) OR ((sourcetype="f5:bigip:asm:syslog") AND ("username.martin"))) OR ((sourcetype="f5:bigip:management:username.management") AND (("get_fullname=martin"))) OR ((sourcetype="fs_notification") AND ((uid=martin))) OR ((sourcetype="oracle:session") AND ((USERNAME=martin))) OR ((sourcetype="oracle:audit:xml") OR (sourcetype="oracle:audit:text") OR ((USERNAME=martin)))) OR ((sourcetype="sophos:appcontrol") AND ((UserName=martin))) OR ((sourcetype="sophos:devicecontrol") AND ((UserName=martin))) OR ((sourcetype="sophos:firewall") AND ((UserName=martin))) OR ((sourcetype="sophos:sec") AND ((UserName=martin))) OR ((sourcetype="sophos:threat") AND ((UserName=martin))) OR ((sourcetype="sophos:utm:ips") AND ((USERNAME=martin))) OR (user=martin) OR (sourcetype="cisco:asa") OR (sourcetype="cisco:fwsm") OR (sourcetype="cisco:pix") OR (sourcetype="oracle:audit:text") OR (sourcetype="oracle:audit:xml")

NOT PRETTY!
Fields Recap

• Each search segment is expanded on its own without context
• props.conf for one sourcetype will radiate into normalizedSearch of other sourcetypes when field names match

• Avoid calculated fields and field aliases entirely where possible
  – Extract fields using standardized names in the first place!
  – Some calculated fields can be replaced with lookups

• Monitor their effects where unavoidable
• Both are fine for fields you only use as output
Reverse Lookups
How reverse lookups work

- **Automatic lookup in props.conf:**
  
  ```
  [splunk_web_access]
  LOOKUP-ul = user_location user OUTPUT location
  ```

- **Reverse lookup:**

  Search for `location` rather than `user`:
  ```
  index=_internal location="Las Vegas"
  ```

- **Splunk translates that into this normalizedSearch:**
  ```
  index=_internal
  (((sourcetype=splunk_web_access) AND
    ((user=Martin) OR (user=Tom)))
  )) OR (location="Las Vegas")
  ```
Actually, I lied...

index=_internal (((sourcetype=splunk_web_access) AND (((((sourcetype=A) AND ((username=Martin))) OR ((sourcetype=B) AND ((uid=Martin))) OR ((sourcetype=audittrail) AND ((uid=Martin))))) OR (user=Martin))) OR (((((sourcetype=A) AND ((username=Tom))) OR ((sourcetype=B) AND ((uid=Tom))) OR ((sourcetype=audittrail) AND ((uid=Tom))))) OR (user=Tom)))))) OR (location="Las Vegas")

• Despite defining the lookup on splunk_web_access, other sourcetypes’ props.conf settings radiate into this search
Expanding to more sourcetypes

- Splunk’s `_internal` index has seven sourcetypes with a `user` field

```plaintext
index=internal ((((sourcetype=scheduler) AND (((sourcetype=A) AND ((username=Martin))) OR ((sourcetype=B) AND ((uid=Martin)))) OR ((sourcetype=audittrail) AND ((uid=Martin))) OR (user=Martin))) OR (((sourcetype=A) AND ((username=Tom))) OR ((sourcetype=B) AND ((uid=Tom))) OR ((sourcetype=audittrail) AND ((uid=Tom))) OR (user=Tom))) OR ((sourcetype=splunk_btool) AND (((((sourcetype=A) AND ((username=Martin))) OR ((sourcetype=B) AND (uid=Martin))) OR ((sourcetype=audittrail) AND (uid=Martin))) OR (user=Martin))) OR (((sourcetype=A) AND ((username=Martin))) OR ((sourcetype=B) AND ((uid=Martin))) OR ((sourcetype=audittrail) AND (uid=Martin))) OR (user=Martin))) OR (((location="Las Vegas") NOT PRETTY!))
```
A location with more than two users?

- 50 users produce a 72kB normalizedSearch that broke PowerPoint
- Noticeable overhead during Parsing Job... phase
- That’s with three field aliases and no calculated fields – imagine 20+!
- Above 50 values per lookup Splunk will revert to „classic“behavior: Load all events, filter later
Mitigation strategies (1)

- Subsearch using inputlookup
  index=_internal [inputlookup user_location | search location="Las Vegas" | fields user]

- Removes the per-sourcetype duplication
- Lets you choose between reverse lookups and *classic* behavior
- Ignores the configured knowledge per sourcetype
- More effort required to write and maintain searches
- Not eventtype-compatible
- Subsearch overhead
Mitigation strategies (2)

- Define the per-sourcetype automatic lookup using sourcetype-specific **input** fields
  
  ```
  LOOKUP-ul = user_location user AS username
  OUTPUT location
  ```

  ✔ Removes the per-alias duplication
  ✔ Transparent to the search and user
  ▶ More effort required to write and maintain knowledge objects
  ▶ Retains the per-sourcetype duplication
Removed 80% of key-value pairs from the normalizedSearch!
Mitigation strategies (3)

- Define the per-sourcetype automatic lookup using sourcetype-specific output fields
  LOOKUP-ul = user_location user OUTPUT location AS sourcetype_location

- Removes the per-sourcetype duplication

- Not transparent at all

- More effort required to write and maintain knowledge objects

- Only really viable if hidden behind eventtypes and/or tags

- Retains the per-alias duplication
Mitigation strategies (4)

- Replace per-sourcetype lookups with broader props.conf stanzas
- Wildcards on source or host
  
  `[source::*access.log*]`

- Unofficial: Wildcards on sourcetype
  
  `[(?:){0}splunk*]`

- ✔️ Removes the per-sourcetype duplication
- ✔️ Transparent to the search and user
- ⚠️ Sourcetype wildcards are neither documented nor supported
- ⚠️ Retains the per-alias duplication
70% key-value pair reduction!
Indexed tokens footnote

- The normalizedSearch generated by reverse lookups can be efficient:
  \[
  \text{index=}_\text{internal} \ \text{location=}"\text{Las Vegas}" \\
  \text{index=}_\text{internal} \\
  (((\text{sourcetype=}\text{splunk_web_access}) \ \text{AND} \\
  ((\text{user=}\text{Martin}) \ \text{OR} \ (\text{user=}\text{Tom})) \\
  )) \ \text{OR} \ (\text{location=}"\text{Las Vegas}")
  \]

- But: Splunk is looking for a literal \text{location=}"\text{Las Vegas}"

- Watch out for \text{location=}0 or similar values that aren’t unique-ish

- This can blow up your scanCount and search duration

- More on dealing with indexed tokens after the end of the deck
How eventtypes work

- Store a search filter or fragments thereof in a reusable box
- No pipes, no subsearches
- Run search and see `searchCanBeEventType` in Job Inspector
  - `eventtype=foo` expands to the stored search fragment
  - `eventtype=f*` expands to an OR’d list of matching eventtypes
- Events that match an eventtype have their `eventtype` field set, regardless of whether the eventtype was used in the search or not
What are eventtypes good at?

- Two different systems likely don’t log login attempts the same way
- Define eventtypes for each system, search on eventtypes
  - Tag your eventtypes and search on tags
- Configured knowledge simplifies searches
- Great way to hide complexity from the searcher
- Add systems to existing searches without touching searches
- Even when not searching on eventtypes, looking at the `eventtype` field helps quickly understand results
Splunk login example

- **TA-splunk, eventtypes.conf:**
  ```search = index=_audit "action=login attempt" NOT "action=search"
  normalizedSearch: ((index=_audit "action=login attempt" NOT "action=search"))```

- **Note how Splunk chose not to use** `action="login attempt"`!

- Avoids the wrath of calculated fields and aliases in the search

- Search relies on structure of raw events instead of field extractions

- The results contain the CIM-compatible `action` regardless
How tags work

- Give a set of `field=value` pairs a common name
- No wildcarded `field=v*` – can be worked around with tagged eventtypes
- `tag=foo` expands to the list of `field=value` pairs individually
- `tag=f*` expands to an OR’d list of matching tags
- Events that match a tag have their `tag field` set accordingly
- For each tagged `field`, additionally set `tag::field`
What are tags good at?

- Homogenize system-specific values to allow unified searches
- Great in combination with eventtypes:
  - Eventtypes define system-specific searches
  - Tags on those eventtypes provide a common interface
  - Searches on those tags don’t need to know the systems particularly well
- Also great in combination with normalized field names and values
  - The unified searches find events over many systems
  - The returned results also provide homogenous data back to you
- That’s the Splunk Common Information Model in a nutshell
- Further reading at [http://docs.splunk.com/Documentation/CIM](http://docs.splunk.com/Documentation/CIM)
Splunk login example

- **TA-splunk, tags.conf:** `[eventtype=splunk_access]`  
  application = enabled  
  authentication = enabled

- **The search** `tag=application tag=authentication yields`  
  `(((index=_audit "action=login attempt" NOT "action=search")))`  
  `(((index=_audit "action=login attempt" NOT "action=search")))`

- **The eventtype is included twice!**
How tags really work

- Search for `tag=application` `tag=authentication`
- Splunk won’t look for `field=value` pairs matching both tags
- Splunk will treat the search like this:
  
  `(tag=application) (tag=authentication)`

- Each tag is expanded individually
- `field=value` pairs will be included once per matching tag
- This can lead to even larger `normalizedSearch` strings!
A real-world example

- Splunk_TA_Oracle defines a handful of tagged eventtypes
- **Four match** `tag=database tag=instance tag=stats`
- Expanding each tag on its own yields sixteen eventtypes!
- Every TA is influenced by every other TA: „Tag Expansion Explosion“
Mitigation Strategies

- Avoid long lists of tags mapping to the same field=value
  - Especially with eventtypes and reverse lookups

- Use distributive properties to reduce tag-eventtype redundancy
  - Instead of tagging every Splunk eventtype with application, consider tagging sourcetype, host, etc. with application
  - Instead of tagging special eventtypes for admin users with privileged, consider tagging those users or a reverse lookup field identifying them

- Look for what actually defines the tag in the real world

- Charm Splunk into optimizing how tags are expanded 😊
Wrapping up
Dos and Don’ts

⚠ Don’t stop using field aliases, calculated fields, reverse lookups, etc.
⚠ Don’t compromise maintainability for small gains

✔ Do take a good look at your environment
✔ Do identify and improve real performance hogs
✔ Do scope knowledge object sharing as narrowly as possible
✔ Do clean up unused knowledge objects and TAs
✔ Do keep monitoring as your knowledge object world grows
Q&A
What Now?

Related breakout sessions and activities...

- You have access to your Splunk at .conf? Talk to me for a quick look!
- Grab the app: https://splunkbase.splunk.com/app/2871

- Duane & George: Beyond the Lookup Glass (Tuesday)
- Amrit & Jag: How splunkd Works (Tuesday)
- Duncan & Julian: Search Efficiency Optimization (Tuesday)
- Niklas: How to use CIM to Gain Security Awareness (Wednesday)
- Dritan: Notes on Optimizing Splunk Performance (later today!)
THANK YOU
Fields: Optimizations Beyond Litsearch
Fields

“Let all values be indexed tokens, for indexed tokens power fast searches.”

- Splunk, late 2000s
Job Inspector continued

- base lispy: How did Splunk crawl its index for events?
- eventCount / scanCount: How efficient was the lispy-induced crawl?

This search has completed and has returned 65 results by scanning 67,296 events in 6.411 seconds.
The following messages were returned by the search subsystem:

```
DEBUG: Configuration initialization for C:\dev\splunk_install\etc took 246ms when dispatching a search (search ID: 1437344782.517)
DEBUG: Subsearch evaluated to the following search expression: splunk
DEBUG: base lispy: [ AND index::_internal splunk ]
DEBUG: search context: user="admin", app="search", bs-pathname="C:\dev\splunk_install\etc"
```

(SID: 1437344782.517) search.log

- limits.conf: [search_info] infocsv_log_level=DEBUG
How Splunk searches for field values (1)

\[
\text{index}=_\text{internal} \quad \text{group}=\text{tpool}
\]

- Assume a field value is present as indexed tokens
- Load events containing those indexed tokens anywhere
  \[
  [ \text{AND index:::_internal tpool} ]
  \]
- Apply field extractions and filter again
  07-21-2015 22:42:52.662 +0200 INFO Metrics -
  group=tpool, name=indexertpool, qsize=0, ...
- Job Inspector: scanCount ≈ eventCount
How Splunk searches for field values (2)

index=_internal qsize=0
[ AND index::_internal 0 ]

- Splunk returns the same event, but takes ages!
  07-21-2015 22:42:52.662 +0200 INFO Metrics -
  group=tpool, name=indexertpool, qsize=0, ...

- Default assumption works great iff field values are unique-ish
Key-Value Tricks (1)

```
index=_internal qsize qsize=0
[ AND index::_internal qsize 0 ]
```

- Take advantage of default key-value field extractions

```
07-21-2015 22:42:52.662 +0200 INFO Metrics -
    group=tpool, name=indexer tpool, qsize=0, ...
```

- Flexible, zero-config speed-up that requires smart searchers!

```
eventCount 18225
scanCount  18691
```
Key-Value Tricks (2)

- Move inline optimization to fields.conf
  
  \[
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>] \\
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>] \\
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>] \\
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>]
\]

- Adds the extra token \text{qsize}, whether the searcher likes it or not

  \[
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>] \\
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>] \\
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>] \\
  \text{INDEXED\_VALUE=} [\text{AND \ qsize <VALUE}>]
\]

- fields.conf applies to all fields of that name, regardless of sourcetype

- This can break for multi-token values!
Key-Value Tricks (3)

- Take it further and assemble longer tokens
  
  ```
  [qsize]
  INDEXED_VALUE=qsize=<VALUE>
  ```

- Rule out events with `qsize!=0` that contain a 0 elsewhere
  
  ```
  index=_internal qsize=0
  [ AND index:::internal qsize=0 ]
  ```

- This will even break for events with `qsize="0"` (major breaker)

- Be sure you know your data before fiddling with fields.conf!
Wildcards (1)

- Splunk will only use indexed tokens for prefixes of wildcarded values

  \texttt{index=_internal component=} \texttt{BucketMove*} \\
  \texttt{[ AND index:\:\_internal bucketmove* ]}

- \texttt{index=_internal component=\*ucketMover} \\
  \texttt{[ AND index:\:\_internal ]}

- Oops!

07-21-2015 22:41:22.999 +0200 INFO \texttt{BucketMover -} \\
\texttt{idx=main Moving bucket=}...
Wildcards (2)

- Force Splunk to use indexed tokens
  
  ```
  index=_internal component=TERM(*ucketMover) [ AND index:::_internal *ucketmover ]
  ```

- Much faster than loading all events, but there’s a penalty for crawling the index without a prefix!

- fields.conf to remove the `TERM()` from all searches
  
  ```
  [component]
  INDEXED_VALUE=<VALUE>
  ```
Fields Recap (Part 2)

- Indexed tokens are king
- scanCount performance hit when indexed tokens can’t be used
- fields.conf optimizations can fix performance, but can break results