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Switch Abstraction Interface

Change Proposal

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| --- | --- |
| **Title** | **Buffer Statistics Tracking (BST) API – A Broadcom Public Extension** |
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# List of Changes

|  |  |  |  |
| --- | --- | --- | --- |
| Version | Changes | Name | Date |
| 1 | Proposal for BST |  | 01/13/16 |
| 2 | Added description and adjusted the API |  | 02/24/16 |
| 3 | Added support for Bulk Statistic Retrieval & Thresholds |  | 05/25/16 |
| 4 | Minor changes to accommodate feedback |  | 06/12/16 |
| 5 | Support for CRUD Model |  | 06/25/16 |
| 6 | Reuse Existing SAI Objects |  | 06/26/16 |
| 7 | Adjust the spec based on community feedback |  | 08/22/16 |
| 8 | Introduce ability for selective buffer tracking and snapshots. Add specific threshold attributes instead of reusing existing watermarks |  | 08/28/16 |
| 9 | Added support for Snapshot Transports |  | 09/20/16 |

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# Overview

Networking Silicon sport a Memory Management Unit which manages packet buffers. The Silicon provides statistics to measure the buffer usage in the MMU. These statistics - Buffer Stats - allow user to get visibility into how the packet buffers are utilized.

This proposal defines a Public extension API for SAI, which allows users monitor the aforementioned buffer usage statistics. A hypothetical Networking silicon is described in terms of typical features and the API to monitor its statistics.

# Proposal

## Statistics

Networking Silicon reports buffer statistics for various on-chip buffers, part of the Memory Management Units. The buffers are presented under various categories, called *realms[[1]](#footnote-2)*. Thus, the buffer statistics are available on a per-realm basis.

The following table provides the list of realms for a typical Networking Silicon and the associated indices for each realm. It also lists all the available statistics for each realm.

|  |  |  |
| --- | --- | --- |
| Realm | Statistic Index | Statistic Name(s) |
| Device |  | data |
| ingress-port-priority-group (port) | priority-group | um-share-buffer-count,  um-headroom-buffer-count |
| ingress-service-pool | service-pool | um-share-buffer-count |
| egress-service-pool | service-pool | um-share-buffer-count,  mc-share-buffer-count |
| egress-uc-queue (port) | queue | uc-buffer-count |
| egress-mc-queue (port) | queue | mc-buffer-count |
| egress-cpu-queue | queue | cpu-buffer-count |

Each buffer, given its parameters, may have one or more than one statistic. For example, the i*ngress Service-Pool* realm buffer, for a given service pool, offers a single statistic: um-share-buffer-count. The eg*ressService-Pool* realm buffer, for a given service pool, offers multiple statistics: *um-share-buffer-count*, *mc-share-buffer-count*.

Much of the statistics are mapped to existing SAI objects. This specification doesn’t define any new mechanism for retrieving values for statistics. Existing attribute get API for the corresponding SAI objects can be used for that purpose. This specification defines a generic mechanism for snapshots - retrieving statistics data in bulk, as well as introduces a notification mechanism for monitoring buffer consumption using thresholds.

The snapshot and notification mechanism introduced in this Specification is generic in nature and can be used by any SAI objects capable of providing statistics and thresholds.

## SAI bst Object

A new object, called **bst**, is added as an attribute (**SAI\_SWITCH\_ATTR\_BST**) for the SAI switch object. This bst provides API to configure the buffer tracker on the silicon. It also provides API to carry out any bulk read/clear operations.

This object can be retrieved using the attribute retrieval function for the SAI switch object.

## Thresholds

Networking Silicon supports configuring threshold levels for each of the statistics. Once a threshold is configured for a statistic, the silicon can notify the CPU when the statistic value exceeds the threshold.

The thresholds can be configured on the silicon by using the attribute configuration function for the appropriate SAI object.

The API **sai\_bst\_threshold\_breach\_event\_notification\_fn** can be used to register a function to get notified of any threshold breach events.

## Tracking Mode

Networking Silicon allows tracking either the current values or the peak values of the statistics. By default, the current values for the statistics are tracked. The required mode can be configured with the **SAI\_BST\_BUFFER\_TRACKING\_MODE** attribute of the **bst** object, using the **sai\_bst\_attribute\_set\_fn** API.

## Snapshots

The Silicon supports taking a current snapshot of all, or selected set, of the statistics, so that they can be used for a comparative analysis. A snapshot may be made by invoking the **sai\_bst\_snapshot\_create\_fn** API. This API returns a snapshot id, which can be used as an attribute for the **sai\_bst\_counters\_get** API to read all statistics from the snapshot.

Additionally, when a statistic values breaches the configured threshold for that statistic, then the driver automatically takes a snapshot of all the statistics and the snapshot id is provided as part of the event notification function.

## Transporting Snapshots

In general, the snapshot data is made available to the local CPU running the SAI control plane. However, there may be cases where the snapshot data may be required to be sent to a remote host/server. To facilitate such a behavior, the user may specify transport object (**sai\_bst\_transporter\_t**) to the **bst** object, using the **SAI\_BST\_TRANSPORTER** attribute.

By default, the **bst** object copies the snapshots to local CPU. If a transporter is provided, the **bst** object will use the transporter provided, to copy the snapshots. This is applicable for all the snapshots created in the switch, including the ones triggered by a threshold breach.

User may also specify an alternate transporter for a specific snapshot by using the **SAI\_BST\_SNAPSHOT\_TRANSPORTER** attribute while creating the snapshot.

It may be noted that the snapshot data may not be available on the local CPU for querying depending on the transporter.

# Specification

## New file saibst.h

### Data Structures & Enumerations

/\*\*

\* BST Statistic. Used at the time of bulk stat retrieval

\* This structure specifies both the statistic and its value.

\*/

typedef struct \_sai\_bst\_statistic\_t {

sai\_object\_id\_t port\_id;

sai\_object\_id\_t buf\_object\_id;

sai\_object\_type\_t object\_type;

uint32\_t statistic\_type;

uint64\_t value;

} sai\_bst\_statistic\_t;

typedef sai\_bst\_statistic\_t sai\_bst\_threshold\_t;

/\*\*

\* BST Statistics Reading Attributes.

\*/

typedef enum \_sai\_bst\_statistics\_attr\_t {

/\*\*

\* Snapshot to read counters from [sai\_bst\_snapshot\_id\_t] (OPTIONAL)

\* If not supplied, the data is read from the hardware and returned

\*/

SAI\_BST\_STATISTICS\_ATTR\_SNAPSHOT\_ID

} sai\_bst\_statistics\_attr\_t;

/\*\*

\* BST Snapshot Attributes.

\*/

typedef enum \_sai\_bst\_snapshot\_attr\_t {

/\*\*

\* Buffers/Statistics for inclusion in snapshot [sai\_object\_type\_t].

\* (OPTIONAL)

\* Specifies the Statistics/Types for a snapshot. Multiple attributes, one for

\* each specific type may be mentioned. If not specified, all silicon

\* supported buffers are included in the snapshot. (DEFAULT)

\*/

SAI\_BST\_SNAPSHOT\_OPTIONS,

/\*\*

\* Transporter Object [sai\_object\_id\_t]. (OPTIONAL)

\* Provides the snapshot transporter object for this snapshot.

\* When the snapshot is made, this transporter will be used

\* to 'copy' the data to the 'transporter-desired' location.

\* In the absense of a transporter, the tracker's default transporter

\* will be used (DEFAULT)

\*/

SAI\_BST\_SNAPSHOT\_TRANSPORTER

} sai\_bst\_snapshot\_attr\_t;

/\*\*

\* BST Tracking Options

\*/

typedef enum \_sai\_bst\_tracking\_options\_t

{

SAI\_BST\_TRACKING\_MODE\_PEAK,

SAI\_BST\_TRACKING\_MODE\_CURRENT

} sai\_bst\_tracking\_options\_t;

/\*\*

\* BST Reporting Options

\*/

typedef enum \_sai\_bst\_reporting\_options\_t

{

SAI\_BST\_REPORTING\_MODE\_BYTES,

SAI\_BST\_REPORTING\_MODE\_PERCENTAGE\_OF\_BUFFER\_SIZE,

} sai\_bst\_reporting\_options\_t;

/\*\*

\* BST Attributes.

\*/

typedef enum \_sai\_bst\_attr\_t {

/\* Number of counters supported [uint32\_t] (READONLY) \*/

SAI\_BST\_ATTR\_NUM\_STATISTICS,

/\* Operational State for the Buffer Tracking [boolean] (OPTIONAL) \*/

/\* Enabled by default \*/

SAI\_BST\_BUFFER\_TRACKING\_OPER\_STATE,

/\* Statistics reporting mode. [sai\_bst\_reporting\_options\_t] (OPTIONAL)\*/

/\* When not specified, reports in number of bytes (DEFAULT) \*/

SAI\_BST\_BUFFER\_REPORTING\_MODE,

/\*\*

\* Buffer Tracker Mode [sai\_bst\_tracking\_options\_t]. (OPTIONAL)

\* Specifies whether the Chip should track the peak values of the

\* buffers or current usage values (DEFAULT)

\*/

SAI\_BST\_BUFFER\_TRACKING\_MODE,

/\*\*

\* Default Transporter Object Id [sai\_object\_id\_t]. (OPTIONAL)

\* Provides a default snapshot transporter object for the Tracker.

\* When a snapshot is made, this transporter will be used

\* to 'copy' the data to the 'transporter-desired' location.

\* In the absense of a transporter, the tracker will copy the

\* data to the local CPU (DEFAULT)

\*/

SAI\_BST\_TRANSPORTER

} sai\_bst\_attr\_t;

/\*\*

\* @brief BST Threshold Breach Event notification

\*/

typedef struct \_sai\_bst\_threshold\_breach\_event\_notification\_t {

/\*\* snapshot id \*/

sai\_object\_id\_t snapshot\_id;

/\*\* Statistic that caused the Threshold Breach event \*/

sai\_bst\_statistic\_t statistic;

} sai\_bst\_threshold\_breach\_event\_notification\_t;

### API

/\*\*

\* Routine Description:

\* @brief Create and return a snapshot object

\* This creates a snapshot in the hardware and copies the snapshot data

\* into the driver. Via the attributes, caller may indicate a preference

\* for snapshot of a specific set of statistics/groups.

\* If no attributes are specified, a complete snapshot of all supported

\* trackers is made.

\*

\* Arguments:

\* @param[out] snapshot\_id - snapshot object

\* @param[in] bst\_id – bst object

\* @param[in] attr\_list – bst trackers for creating a snapshot

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_snapshot\_create\_fn)(

\_Out\_ sai\_object\_id\_t \*snapshot\_id,

\_In\_ sai\_object\_id\_t bst\_id,

\_In\_ uint32\_t attr\_count,

\_In\_ sai\_attribute\_t \*attr\_list /\* sai\_bst\_snapshot\_attr\_t \*/

);

/\*\*

\* Routine Description:

\* @brief Return the object id for current snapshot maintained in the driver

\*

\* Arguments:

\* @param[out] snapshot\_id - snapshot object

\* @param[in] bst\_id – bst object

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_current\_snapshot\_get\_fn)(

\_Out\_ sai\_object\_id\_t \*snapshot\_id,

\_In\_ sai\_object\_id\_t bst\_id

);

/\*\*

\* Routine Description:

\* @brief Deletes a specified snapshot object.

\*

\* Arguments:

\* @param[in] snapshot\_id - snapshot object to be removed.

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_snapshot\_remove\_fn)(

\_In\_ sai\_object\_id\_t \*snapshot\_id

);

/\*\*

\* Routine Description:

\* @brief Get values for specified BST attributes.

\*

\* Arguments:

\* @param[in] bst\_id – bst object id

\* @param[in] attr\_count - number of attributes

\* @param[inout] attr\_list - array of attributes

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_attribute\_get\_fn)(

\_In\_ sai\_object\_id\_t bst\_id,

\_In\_ uint32\_t attr\_count,

\_Inout\_ sai\_attribute\_t \*attr\_list

);

/\*\*

\* Routine Description:

\* @brief Set BST attribute value(s).

\*

\* Arguments:

\* @param[in] bst\_id - bst id

\* @param[in] attr - attribute

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_attribute\_set\_fn)(

\_In\_ sai\_object\_id\_t bst\_id,

\_In\_ uint32\_t attr\_count,

\_In\_ sai\_attribute\_t \*attr\_list

);

/\*\*

\* Routine Description :

\* @brief Obtain the value for all statistics, either directly

\* from hardware or from a snapshot.

\*

\* Arguments:

\* @param[in] bst\_id – bst object id

\* @param[in] attr – specifies the optional snapshot id

\* @param[inout] stat\_count - number of statistics (required/provided)

\* @param[inout] statistics - statistics (allocated/provided)

\*

\* Return Values :

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_statistics\_get\_fn)(

\_In\_ sai\_object\_id\_t bst\_id,

\_In\_ uint32\_t attr\_count,

\_In\_ sai\_attribute\_t \*attr\_list,

\_Inout\_ uint32\_t \*stat\_count,

\_Inout\_ sai\_bst\_statistic\_t \*statistics

);

/\*\*

\* Routine Description :

\* @brief Clear all the thresholds

\*

\* Arguments:

\* @param[in] bst\_id – bst object id

\*

\* Return Values :

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_thresholds\_clear\_fn)(

\_In\_ sai\_object\_id\_t bst\_id

);

/\*\*

\* Routine Description:

\* @brief Snapshot Transport Function

\*

\* Arguments:

\*

\* Return Values :

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_transport\_fn)(void);

/\* Transporter dispatch table \*/

typedef struct \_sai\_bst\_transporter\_t

{

sai\_bst\_transport\_fn bst\_snapshot\_transport;

} sai\_bst\_transporter\_api\_t;

/\*\*

\* Routine Description:

\* @brief Create and return a Transport object

\* This creates a transport object for copying the snapshot data

\* to the desired location

\*

\* Arguments:

\* @param[out] transporter\_id - Transporter object

\* @param[in] bst\_id – bst object

\* @param[in] api – Transport functions dispatch table

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_transporter\_create\_fn)(

\_Out\_ sai\_object\_id\_t \*transporter\_id,

\_In\_ sai\_object\_id\_t bst\_id,

\_In\_ sai\_bst\_transporter\_api\_t api

);

/\*\*

\* Routine Description:

\* @brief Deletes a specified Transporter object.

\*

\* Arguments:

\* @param[in] transporter\_id - transporter object to be removed.

\*

\* Return Values:

\* @return SAI\_STATUS\_SUCCESS on success

\* Failure status code on error

\*/

typedef sai\_status\_t(\*sai\_bst\_transporter\_remove\_fn)(

\_In\_ sai\_object\_id\_t \*transporter\_id

);

typedef struct \_sai\_bst\_api\_t

{

sai\_bst\_snapshot\_create\_fn bst\_snapshot\_create;

sai\_bst\_snapshot\_remove\_fn bst\_snapshot\_remove;

sai\_bst\_current\_snapshot\_get\_fn bst\_current\_snapshot\_get;

sai\_bst\_attribute\_get\_fn bst\_attribute\_get;

sai\_bst\_attribute\_set\_fn bst\_attribute\_set;

sai\_bst\_statistics\_get\_fn bst\_statistics\_get;

sai\_bst\_thresholds\_clear\_fn bst\_thresholds\_clear;

sai\_bst\_transporter\_create\_fn bst\_transporter\_create;

sai\_bst\_transporter\_remove\_fn bst\_transporter remove;

} sai\_bst\_api\_t;;

## Changes to sai.h

typedef enum \_sai\_api\_t {

…

SAI\_API\_BST = 0x200, /\* sai\_bst\_api\_t \*/

}

## Changes to saitypes.h

The following are the changes to the saitypes.h file.

* The union **sai\_object\_type\_t** is enhanced to include the following new object types:
* **SAI\_OBJECT\_TYPE\_BST**
  + **SAI\_OBJECT\_TYPE\_BST\_SNAPSHOT**,
  + **SAI\_OBJECT\_TYPE\_BST\_TRANSPORTER**

## Changes to saiswitch.h

The following are the changes to the saiswitch.h file

* The union **sai\_switch\_attr\_t** is enhanced to include following new attributes:
  + **SAI\_SWITCH\_ATTR\_BST**,
  + **SAI\_SWITCH\_ATTR\_BUFFER\_USAGE\_BYTES**
  + **SAI\_SWITCH\_ATTR\_BUFFER\_THRESHOLD**.

## Changes to saibuffer.h

The following are the changes to the saibuffer.h file

* The enumeration **sai\_ingress\_priority\_group\_stat\_counter\_t** is enhanced to include the following new counters:
  + **SAI\_INGRESS\_PRIORITY\_GROUP\_STAT\_HEADROOM\_BYTES**
* A new enumeration **sai\_ingress\_priority\_group\_threshold\_t** is added, which has the following entries (thresholds):
  + **SAI\_INGRESS\_PRIORITY\_GROUP\_HEADROOM\_THRESHOLD**
  + **SAI\_INGRESS\_PRIORITY\_GROUP\_SHARED\_THRESHOLD**
* The enumeration **sai\_buffer\_pool\_stat\_counter\_t** is enhanced to include the following new counters:
  + **SAI\_BUFFER\_POOL\_STAT\_MULTICAST\_CURR\_OCCUPANCY\_BYTES**
* A new enumeration **sai\_buffer\_pool\_threshold\_t** is added, which has the following entries (thresholds)
  + **SAI\_BUFFER\_POOL\_MULTICAST\_THRESHOLD**
  + **SAI\_BUFFER\_POOL\_THRESHOLD**

## Changes to saiqueue.h

The following are the changes to the saiqueue.h file

* A new enum **sai\_queue\_threshold\_t** is added, which has the entry (threshold) **SAI\_QUEUE\_THRESHOLD**

# Examples

## Setting Up Buffer Tracking

sai\_object\_t bst;

sai\_attribute\_t switch\_attrs[1];

sai\_attribute\_t bst\_attrs[4];

sai\_object\_t transporter;

/\* Get BST Object from switch \*/

switch\_attrs[0].id = (sai\_attr\_id\_t)SAI\_SWITCH\_ATTR\_BST;

get\_switch\_attribute(switch\_object\_id, 1, &switch\_attrs[0]);

bst = switch\_attrs[0].oid;

/\* Create the Custom Transport \*/

sai\_bst\_transporter\_api\_t dispatch;

dispatch.bst\_snapshot\_transport = my\_transport\_fn;

bst\_transporter\_create(&transporter, &dispatch);

/\* Setup BST Global Configuration \*/

/\* Enable BST Tracking \*/

bst\_attrs[0].id = (sai\_attr\_id\_t)SAI\_BST\_BUFFER\_TRACKING\_OPER\_STATE;

bst\_attrs[0].value.booldata = 1;

/\* let the reporting be in percentages \*/

bst\_attrs[1].id = (sai\_attr\_id\_t)SAI\_BST\_BUFFER\_REPORTING\_MODE;

bst\_attrs[1].value.s32 = SAI\_BST\_REPORTING\_MODE\_PERCENTAGE\_OF\_BUFFER\_SIZE;

/\* we want peak values of buffer usage rather than current usage \*/

bst\_attrs[2].id = (sai\_attr\_id\_t)SAI\_BST\_BUFFER\_TRACKING\_MODE;

bst\_attrs[2].value.s32 = SAI\_BST\_TRACKING\_MODE\_PEAK;

/\* Custom Transport \*/

bst\_attrs[3].id = (sai\_attr\_id\_t)SAI\_BST\_TRANSPORTER;

bst\_attrs[3].value.oid = transporter;

/\* apply the configuration \*/

bst\_attribute\_set(bst, 3, &bst\_attrs[0]);

## Creating and Reading from a Snapshot

int num\_counters = 0;

sai\_bst\_statistic\_t \*stat\_list;

sai\_attribute\_t bst\_attrs[3];

sai\_object\_t snapshot;

sai\_object\_t bst;

/\* Obtain BST object \*/

...

/\* findout the number of available statistics \*/

bst\_attrs[0].id = (sai\_attr\_id\_t)SAI\_BST\_ATTR\_NUM\_STATISTICS;

bst\_attribute\_get(bst, 1, &bst\_attrs[0]);

num\_counters = bst\_attrs[0].value.s32;

/\* allocate memory for 'num\_counters' of 'sai\_bst\_statistic\_t' counters \*/

...

/\* create a complete snapshot \*/

bst\_snapshot\_create(&snapshot, bst, 0, &bst\_attrs[0]);

/\* read from snapshot \*/

bst\_attrs[0].id = (sai\_attr\_id\_t)SAI\_BST\_STATISTICS\_ATTR\_SNAPSHOT\_ID;

bst\_attrs[0].value.oid = snapshot;

bst\_statistics\_get(bst, 1, &bst\_attrs[0], &num\_counters, stat\_list);

## Creating a Partial Snapshot

/\* create a partial snapshot\*/

sai\_attribute\_t bst\_attrs[1];

sai\_object\_t snapshot;

sai\_object\_t bst;

...

/\* Intersted in Ingress-Port-Priority-Group Statistics \*/

bst\_attrs[0].id = (sai\_attr\_id\_t)SAI\_BST\_SNAPSHOT\_OPTIONS;

bst\_attrs[0].value.s32 = SAI\_OBJECT\_TYPE\_PRIORITY\_GROUP;

...

/\* create the a required snapshot \*/

bst\_snapshot\_create(&snapshot, bst, 1, &bst\_attrs[0]);

1. A hypothetical name [↑](#footnote-ref-2)