Hypersistent Sketch Algorithm

1 Hot Part (Stage 3)

Algorithm 1: Insert_Stage3(e)

```
Input: An item $e$, entries within buckets containing IDs $keys$, persistence $per$,
       and status $flag$
$replace = null$;
$bucket \leftarrow L_3[H(e)]$;
for $entry \in bucket$ do
    if $entry.key == null \;||\; (entry.key == e \;\&\&\; entry.flag == On)$ then
        $entry.key \leftarrow e$;
        $entry.flag \leftarrow$ Off;
        $entry.per \leftarrow entry.per + 1$;
        return;
    end
    ;                                          // ▷ If match entry is found
    if $replace == null \;||\; entry.per < replace.per$ then
        $replace \leftarrow entry$;
    end
    ;                                          // ▷ If match entry not found
end
if $H(e)\ \%\ (replace.per + 1) == 0$ then
    $replace.item \leftarrow e$;
    $replace.per \leftarrow replace.per + 1$;
    $replace.flag \leftarrow$ Off;
end
;                                              // ▷ Probabilistic replacement
```

2 Cold Filter (Stage 2)

```
Algorithm 2: Insert_Stage2(e)
Input: An item $e$, buckets in $L_1, L_2$ with persistence counters $per$ and status
       flags $flag$
Output: Insertion in stage 2
$v1 = min_{1 \leq i \leq d_1} L_1[i][h_i(e)].per$;
if $v1 < \Delta_1$ then
    for $i$ from $1 \rightarrow d_1$ do
        $b_1 \leftarrow L_1[i][h_i(e)]$;
        if $b_1.per == v1$ && $b_1.flag == On$ then
            $b_1.per \leftarrow b_1.per + 1$;
            $b_1.flag \leftarrow$ Off;
        end
    end
    return $true$;
    ;                                   // ▷Successful insertion in $L_1$
end
$v2 = min_{1 \leq i \leq d_2} L_2[i][g_i(e)].per$;
if $v2 < \Delta_2$ then
    for $i$ from $1 \rightarrow d_2$ do
        $b_2 \leftarrow L_2[i][g_i(e)]$;
        if $b_2.per == v2$ && $b_2.flag == On$ then
            $b_2.per \leftarrow b_2.per + 1$;
            $b_2.flag \leftarrow$ Off;
        end
    end
    return $true$;
    ;                                   // ▷Successful insertion in $L_2$
end
return $false$
```

3 Burst Filter (Stage 1)

Algorithm 3: Insert_Stage1(e)

```
Input: An item $e$, cells in bucket array $B$ containing IDs $keys$
Output: Insertion success in Stage 1
for $cell \in B_{f(e)}$ do
    if $cell.id == null \mid\mid cell.id == e.id$ then
        $cell.id = e.id$;
        return true;
    end
end
return false;
```

4 Complete Insertion of Hypersistent Sketch

Algorithm 4: Insert(e)

```
Input: Item $e$.
if $Insert\_Stage1(e)$ then
    return;
end
if $Insert\_Stage2(e)$ then
    return;
end
$Insert\_Stage3(e)$;
return;
```

5 Persistence Query

Algorithm 5: Query

```
Input: Item $e$
Output: The persistence of $e$
$ret \leftarrow 0$;
$v1 \leftarrow min_{1 \leq i \leq d_1}(L_1[i][h_i(e)])$;
if $v1 < \Delta_1$ then
    return $v1$;
end
$ret \leftarrow ret + v1$;
$v2 = min_{1 \leq i \leq d_2}(L_2[i][g_i(e)])$;
if $v2 < \Delta_2$ then
    return $ret + v2$;
end
$ret \leftarrow ret + v2$;
;                                                  // ▷ Cold Filter
$bucket \leftarrow L_3[H(e)]$;
for $entry \in bucket$ do
    if $entry.key == e$ then
        $ret \leftarrow ret + entry.per$;
    end
endfor
;                                                  // ▷ Hot Part
return $ret$;
```