802.1Qbp – ECMP Multicast Load Spreading

Ben Mack-Crane

(ben.mackcrane@huawei.com)

Observations on Multicast ECMP

- Multicast cannot use the unicast load spreading mechanism
  - Must forward on multiple ports (cannot select just one)
  - Random selection & replication can lead to duplication & loops
- ECMP for unicast traffic makes congruence (unicast-multicast and bi-directional) either easy or impractical (depending on how the definition is adjusted)
  - In either case congruence is not a concern with ECMP
- Multicast traffic must be constrained to a tree
  - to avoid loops and duplicate frames

Spreading Multicast Traffic

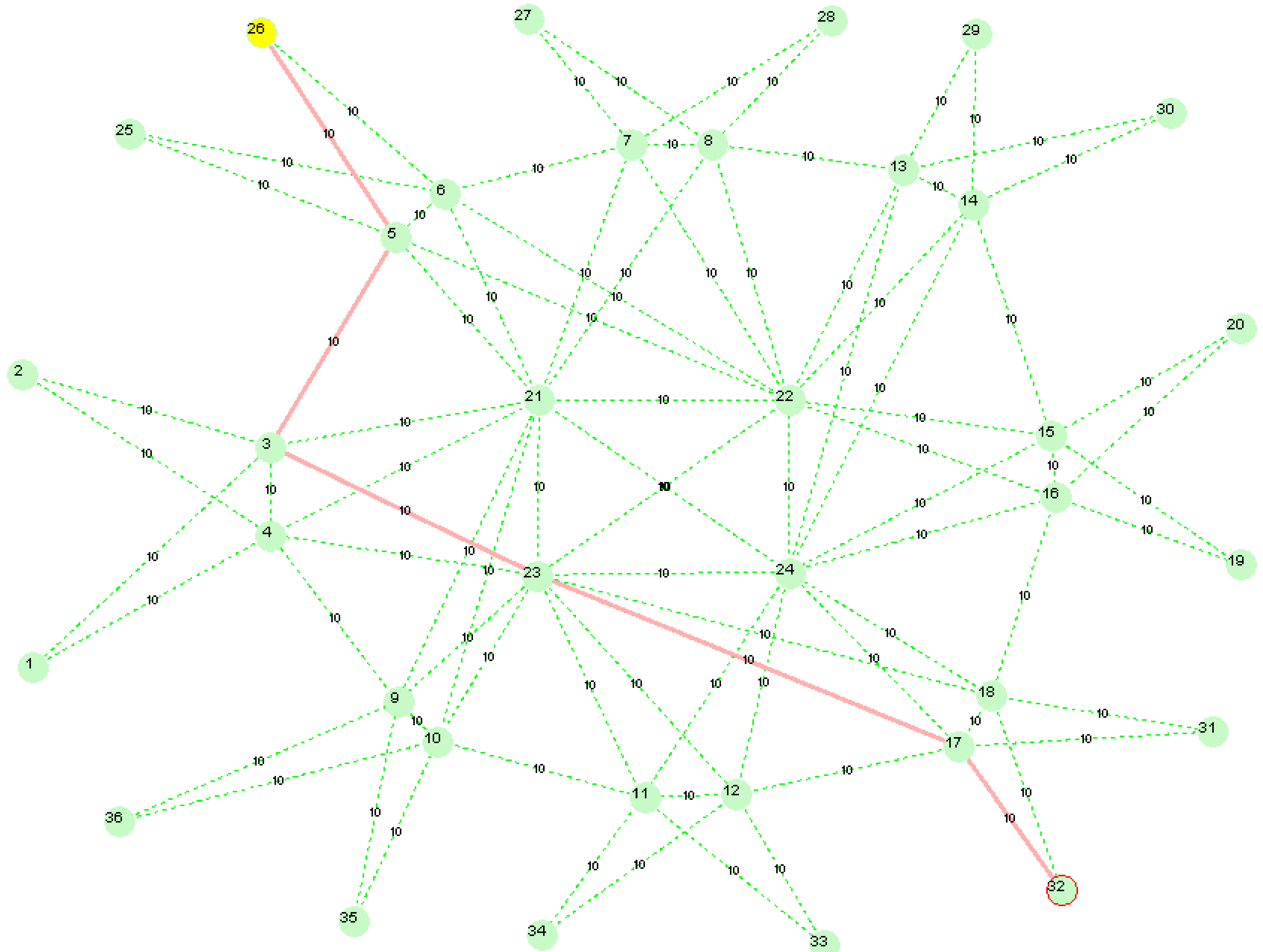
- In SPBM each service instance (I-SID) has distinct group addresses used to carry client multicast/broadcast traffic
  - Group addresses composed from SPSourceID & I-SID
  - # multicast flows = #service instances * #edge nodes
- Multicast filtering governed by VID and address (not Flow ID)
- Each multicast address can be independently routed
- Could assign each address to a different SPT
  - All nodes must agree on assignment to produce consistent forwarding state
  - Potentially large calculation (tree per address)
  - Probably more addresses than SPTs anyway

One Approach – Hashed SPT per Source

- Select “random” tree from SPT set for each source node
  - Select from all SPTs, not just those selected by .1aq tie-breakers
- Use this tree for all flows from that node
  - All I-SID multicast from source node use same tree
  - I-SIDs have varied endpoints, so some spreading within tree
- Use hash (e.g., FNV) to select one “parent” from set of equal cost parents calculated for unicast ECMP
  - Modest addition to route calculation
  - Include source node MAC address in hash to create variation

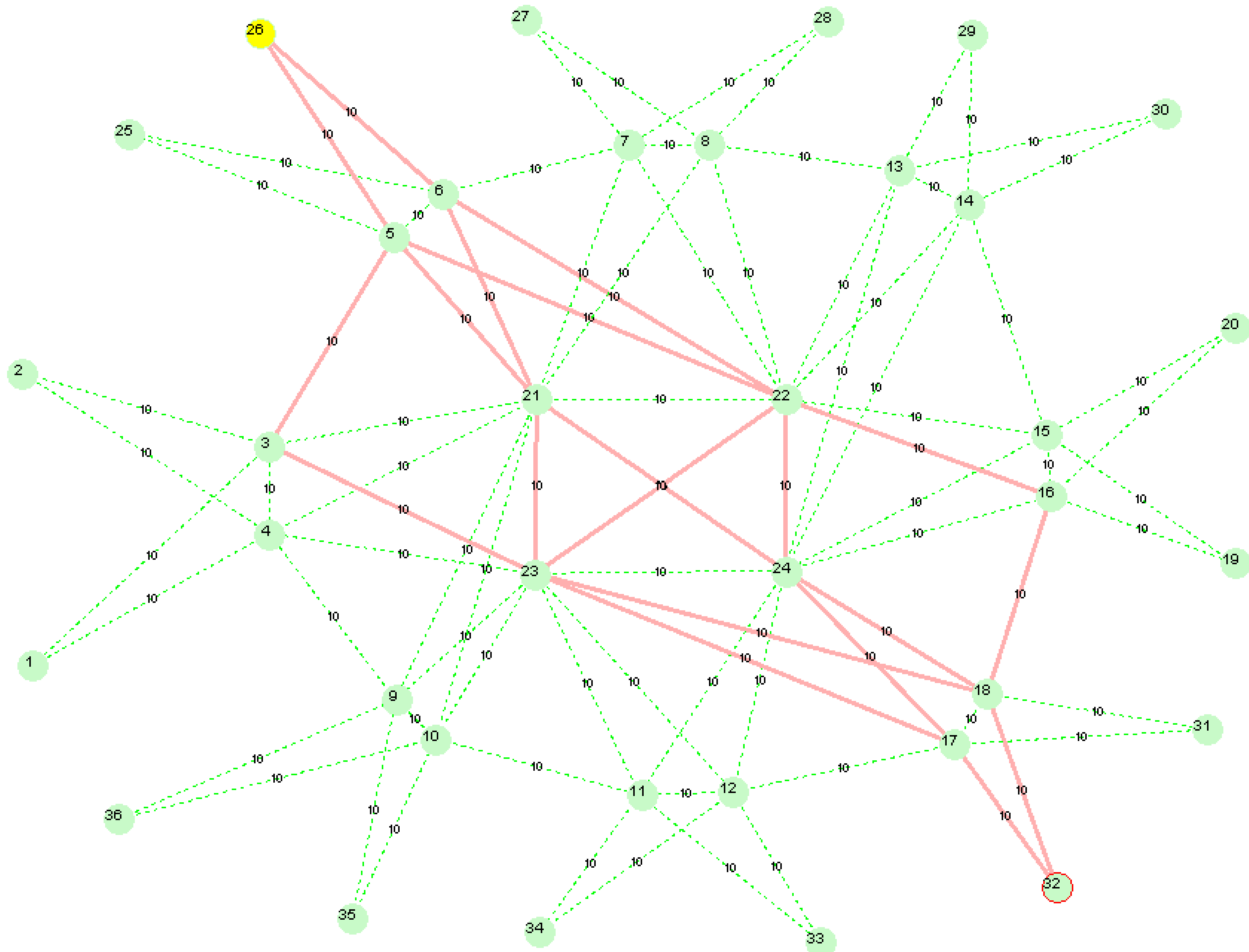
- Tried this out in an SPB simulator…

Unicast SPB, e.g. between 26 and 32



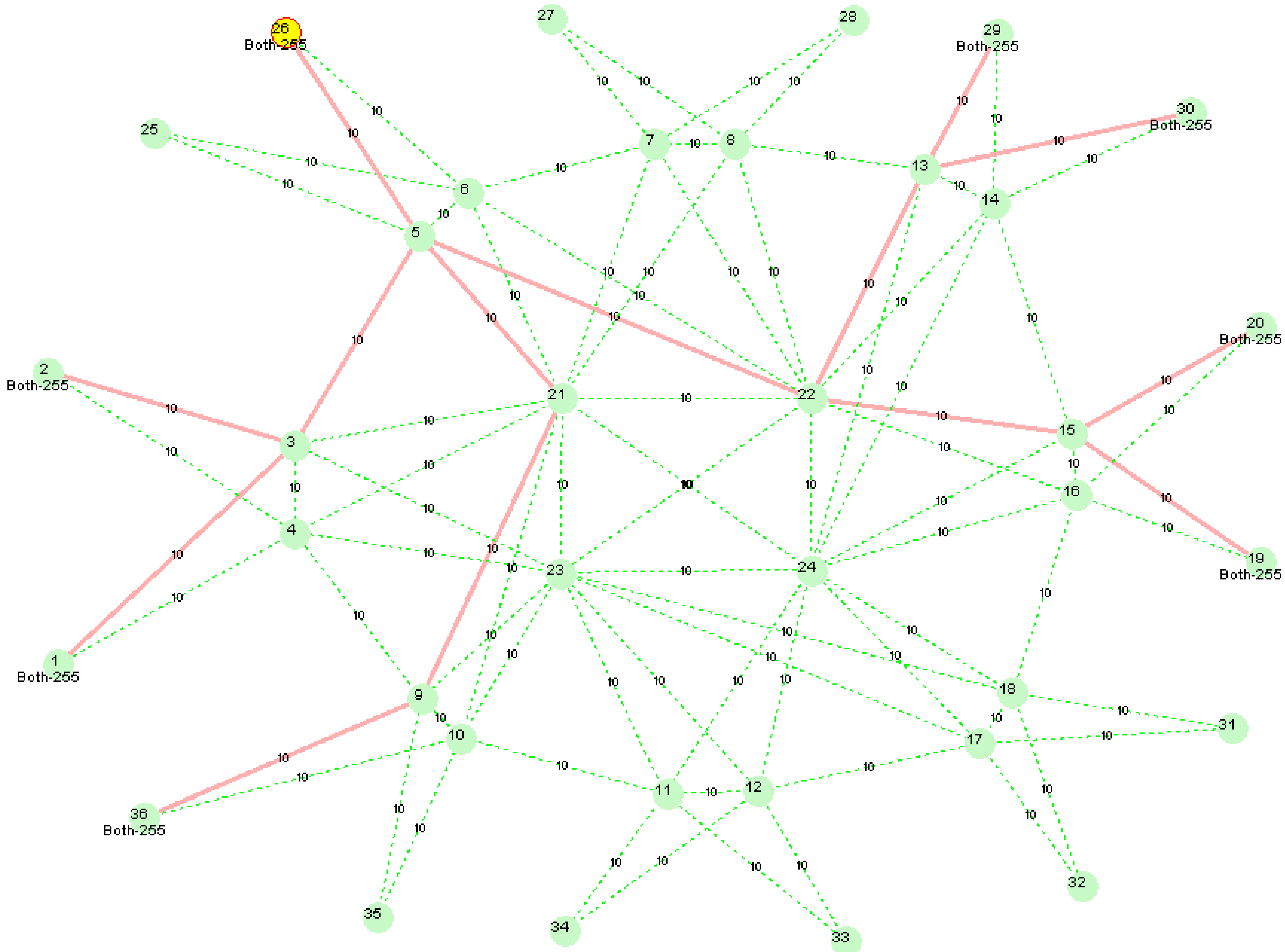
SPB selects a single path using an ECT tie-breaking function.

Unicast ECMP, e.g. between 26 and 32



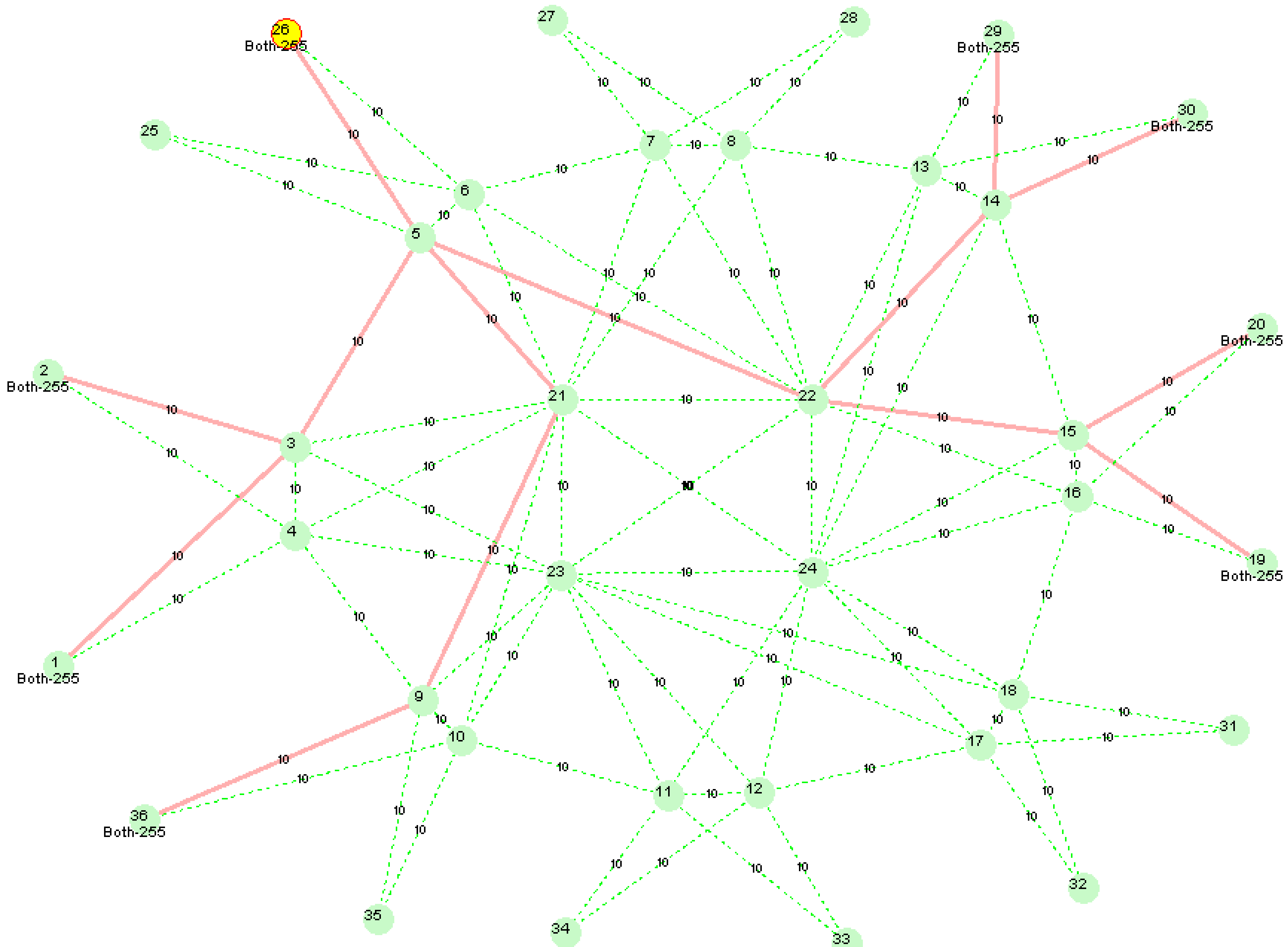
ECMP load spreading utilizes all links on equal cost paths for unicast traffic.

SPB Multicast Tree, e.g. I-SID 255 from 26



Multicast selects links from one equal cost tree using ECT tie-breaker.

ECMP Multicast Tree, e.g. I-SID 255 from 26



Multicast load spreading selects links from all equal cost paths using a hash function (in this case FNV).

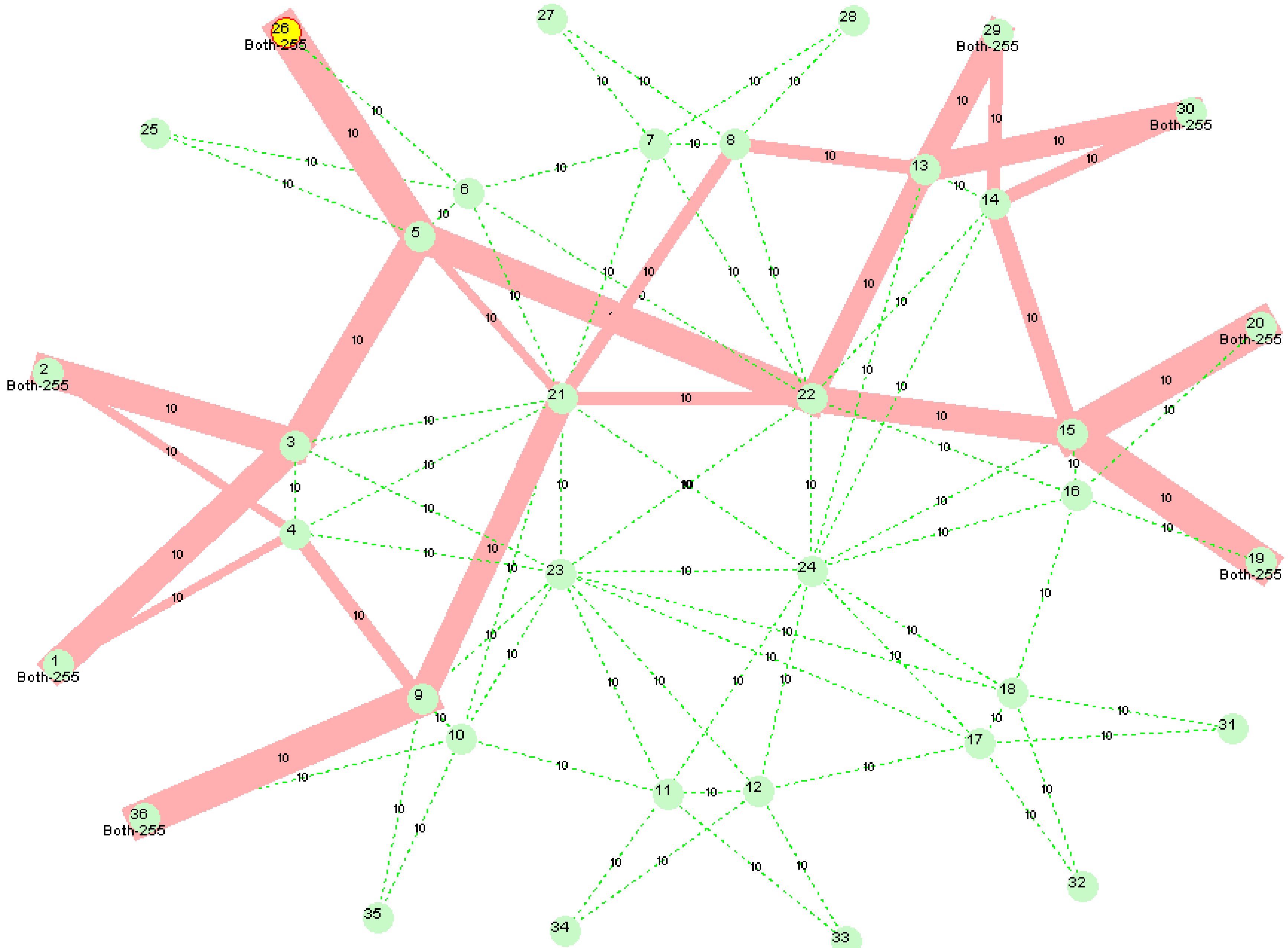
Code for Parent FNV hash

```
#define C1AQ_SYST_HASH_PARENT(result, syst, r, n)               \
{   register tUINT32 hash = 0x811C9DC5;                         \
    register tUINT64 fodder;                                    \
    register tUINT32 fnvPrime = 0x01000193;                     \
    register tUINT32 best = 0;                                  \
    register int k,m, np = syst->node[n].np;                    \
    for (m=0; m<np; m++)                                        \
    {                                                           \
        fodder = syst->node[r].sysIdMac[0];                   \
        for(k=0;k<7;k++)                                        \
        {                                                       \
            hash = hash ^ (fodder & 0x000000ff);                \
            hash = hash * fnvPrime;                             \
            fodder = fodder >> 8;                               \
        }                                                       \
        fodder = syst->node[syst->node[n].parent[m]].sysIdMac[0]; \
        for(k=0;k<7;k++)                                        \
        {                                                       \
            hash = hash ^ (fodder & 0x000000ff);                \
            hash = hash * fnvPrime;                             \
            fodder = fodder >> 8;                               \
        }                                                       \
        if (hash > best)                                        \
        {                                                       \
            best = hash;                                        \
            result = m;                                         \
        }                                                       \
    }                                                           \
    result = (m==0 ? -1 : syst->node[n].parent[result]);    \
}
```

This is the code in the SPB simulator used to generate these slides – I'm not sure this is a correct implementation of FNV – comments welcome!

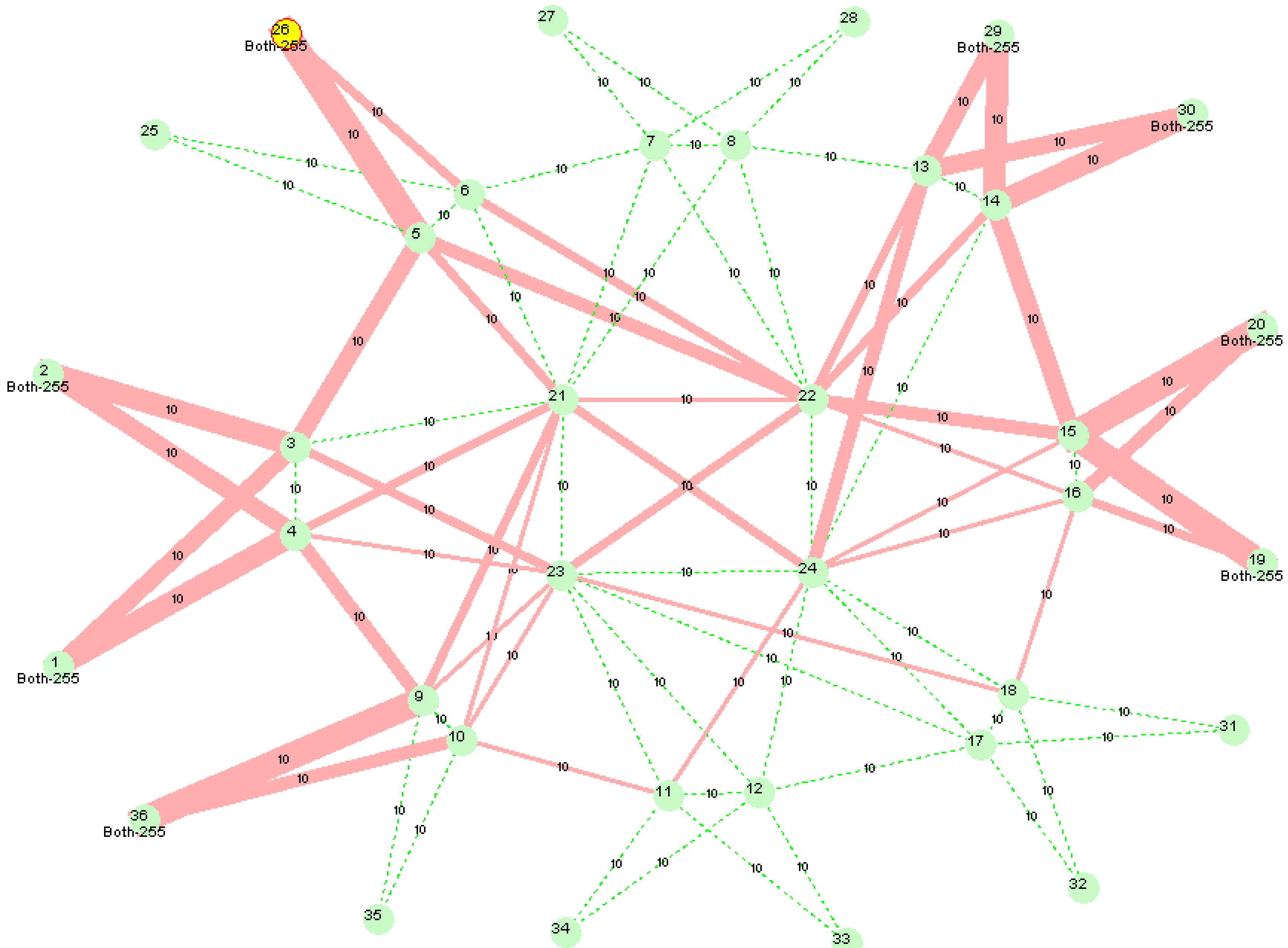
- Random parent selection from ECMP set to produce source tree
- Uses Highest Random Weight (RFC 2991) to minimize impact of topology change

All SPB Multicast Trees, e.g. I-SID 255



Set of multicast trees are congruent.

All Multicast Trees, e.g. I-SID 255



Multicast load spreading selects links from all equal cost paths using a hash function (in this case FNV). Different trees are selected for each root by including root MAC address in hash.

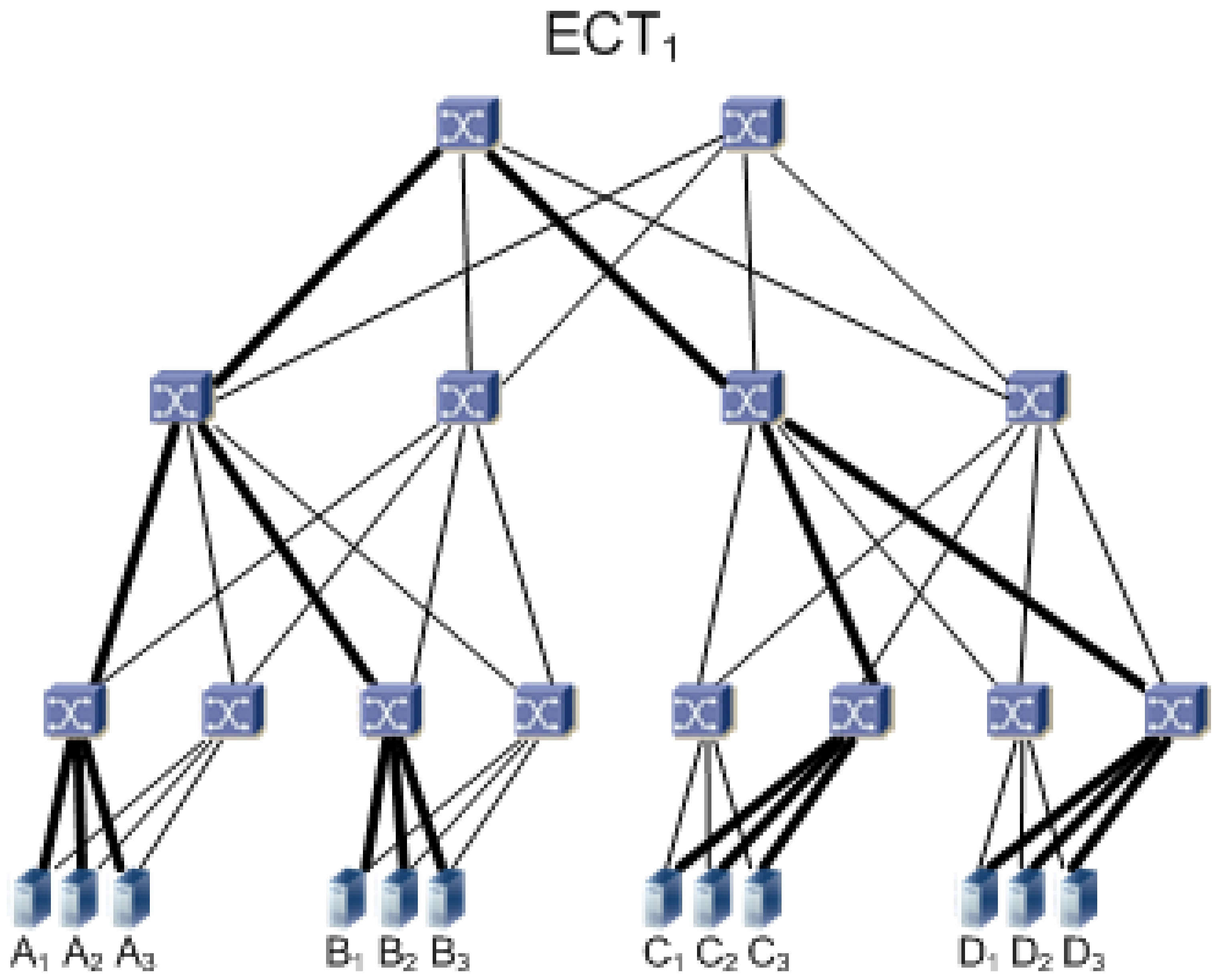
Observations on this Approach

- ECMP algorithm used for both unicast and multicast
  - Provides load spreading for both types of traffic
- Multicast spreading uses a standard hash (pseudo-random)
- Good computational performance (relatively minor change)
- No provisioning required! (just like unicast)
  - No selection or configuration of VID or tie-breaker needed
- Propose further study of spreading performance and selection of a standard hash algorithm for use in multicast route calculation

One Concern – Multicast State Scaling

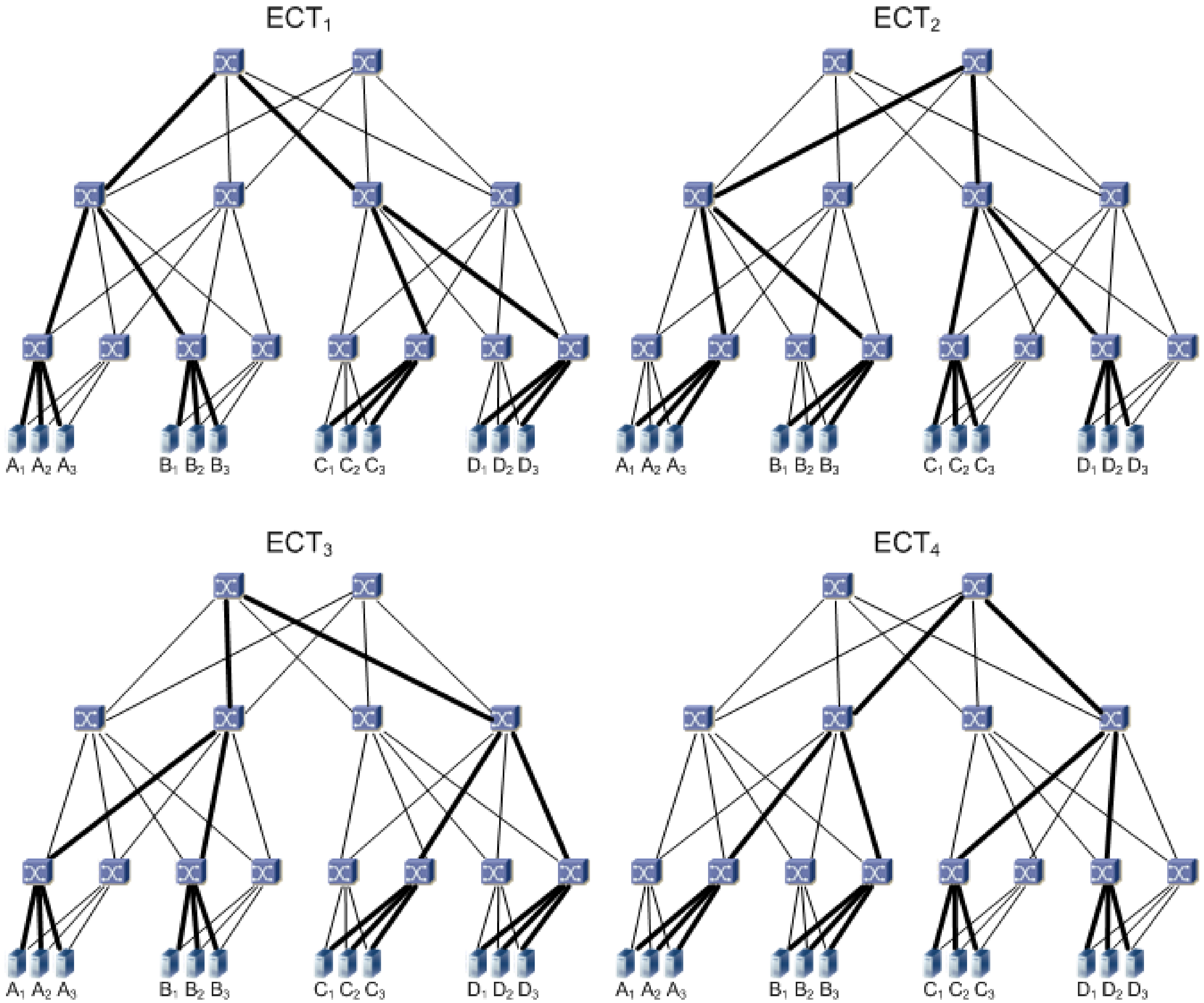
- Feedback expressing concern about scaling of multicast state
  - Multicast state is required per group address (I-SID endpoint)
- In networks with many BSIs with many endpoints each…
  - Result is many many group addresses registered in FDB
- E.g., virtual desktop VLAN may have 100s of endpoints (1000's of users)
  - With default .1aq this means 100s of group addresses
  - And that is just for one I-SID!
- In large DC networks many group addresses may be assigned to the same tree (many more addresses than trees)
- Can we provide better scaling behavior?

Loop Free SPT Set



- Data center “fat tree” network architecture has a very regular structure
- A shortest path tree can match an SPT Set (i.e., be SPT from all endpoints)
- Using a shared tree for multicast reduces the forwarding state required (i.e., can use one address per service instead of one address per service endpoint)

ECMP with Shared Trees



- Shortest path trees rooted at spine nodes can form a balanced cover set
- Load spread by random assignment of each service instance to one of the shared trees
- Can realize significant reduction in multicast state (e.g., order of magnitude or more)

Observations on Shared Trees

- .1aq ECT Algorithm knobs may be used to tune trees
  - Create a set of trees that use all links
  - Each link used by the same number of trees (absent faults)
- VIP Default Backbone Destination address default is a single value per I-SID (BSIGA)
- Worthwhile to study shared trees and the options for supporting this feature

Multicast ECMP in 802.1Qbp

- So far in Qbp we have discussed the following:
  - Treat multicast the same as in .1aq (one congruent SPT set)
  - Provision multiple .1aq SPT Sets (tie-breakers) in one VLAN
  - Automatic selection from all possible SPTs, one per source node
  - Support shared trees to address FDB scaling issues
- These are four out of many possibilities
- Need to consider benefits of supporting various options
  - Better spreading characteristics
  - Less configuration (e.g. fully automatic)
  - Better fit with existing standards
  - Ability to control traffic placement when needed

ECMP Multicast Attributes

- **Granularity of SPT selection?**
  - One (per region)
  - One per source node
  - N per source node
  - One per address
- **How many SPTs in selection set?**
  - One .1aq tie-breaker subset
  - N .1aq tie-breaker subsets
  - All SPTs
- **How many group addresses?**
  - One per I-SID endpoint
  - One per I-SID (requires shared tree)
- **Selection of SPT**
  - Automatic (requires standard hash)
  - Provisioned (may require ISIS-SPB extension)
- **Assignment of I-SID to SPT**
  - Automatic (requires standard hash)
  - Provisioned (may require ISIS-SPB extension)

Some Possible (Desirable?) Combinations

- **All Automatic: maximize number of trees, spreading opportunity**
  - All SPTs (e.g., hash selection from ECMP)
  - One SPT per source node (to keep computation tractable)
  - One address per I-SID endpoint (so shared trees are not required)

- **All Provisioned: minimize options, maximize control**
  - One .1aq tie-breaker subset
  - One SPT per source node
  - One address per I-SID endpoint

- **Minimize multicast FDB state**
  - N .1aq tie-breaker trees (to provide cover set)
  - N SPTs per source node
  - One address per I-SID (requires shared tree)
  - Provisioned (or Automatic?)

Need to choose combinations to support in 802.1Qbp.