Constructing VPNs in Pathlet Routing

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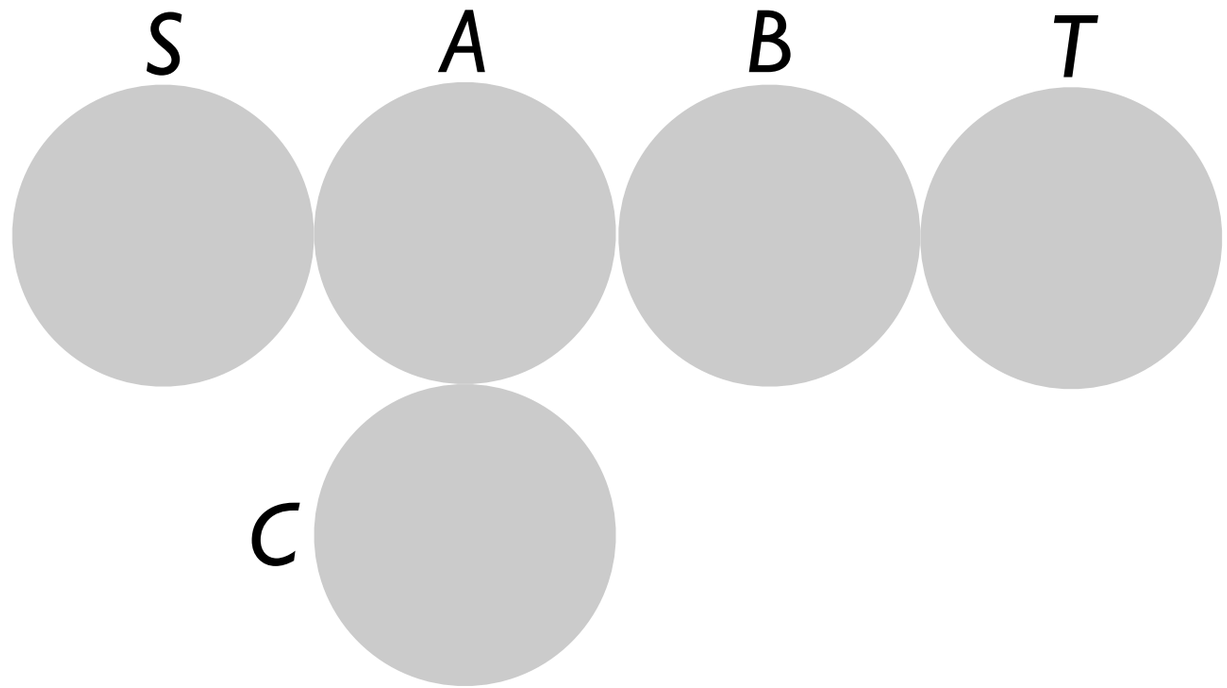
VPNs in Pathlet Routing

Suppose we have this AS-level topology and we want to set up a VPN between *S* and *T*, so that so they can reach each other, but other nodes (in particular, *C*) cannot send to or receive from them. Unlike the typical case in the Internet today, this VPN spans multiple providers (*A* and *B*).

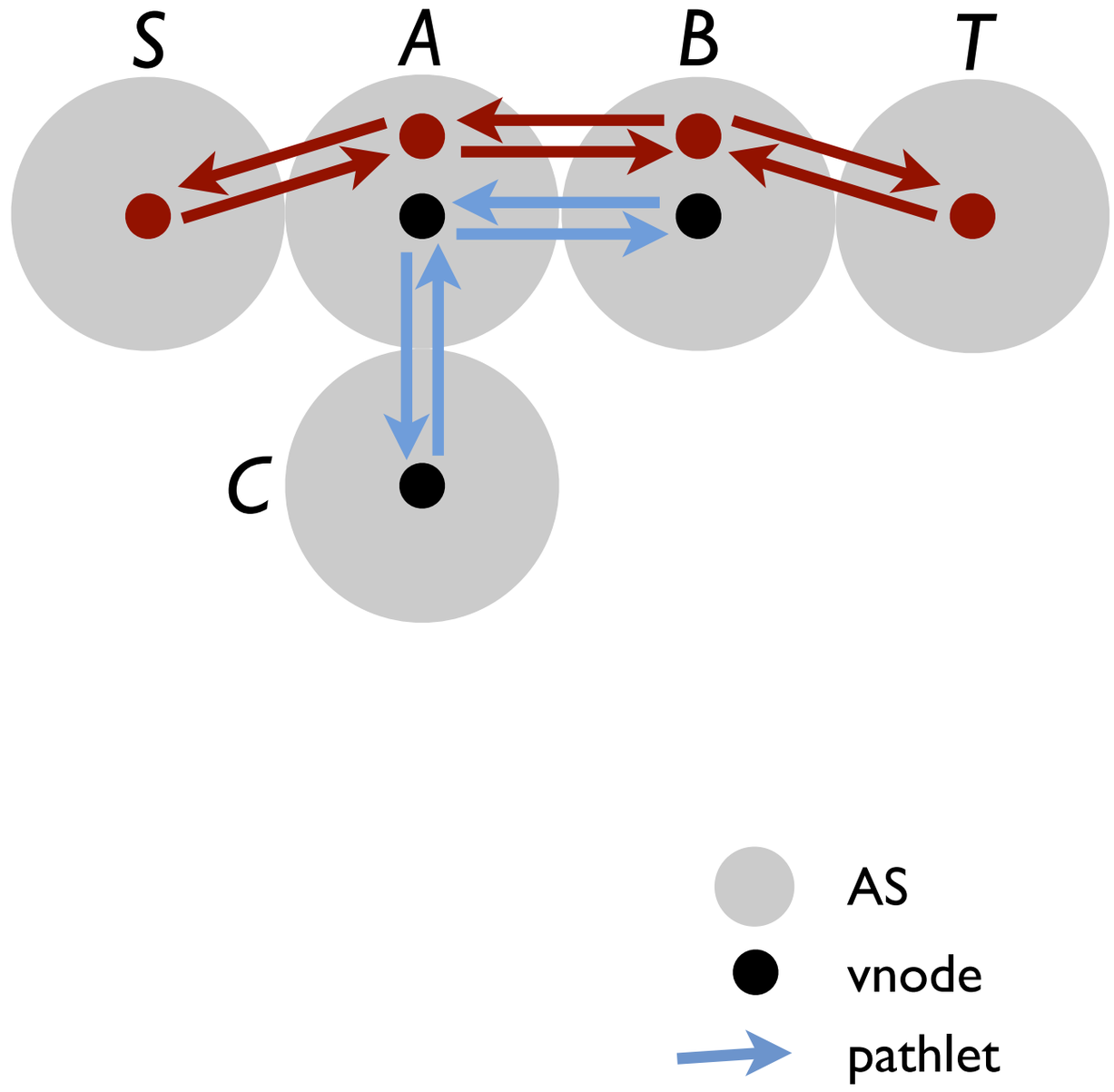


Meanwhile, all the nodes in the interior (*A*,*B*,*C*) should be able to communicate freely.

We'll assume nodes along the VPN path cooperate.

What we basically want

We *basically* want the vnodes and pathlets shown at right. *S* and *T* have their private connection not accessible by *C* even though *C* can route to, and through, *A* and *B*. As you can see, it's easy to construct a virtual private network, since pathlet routing effectively routes on a virtual topology.



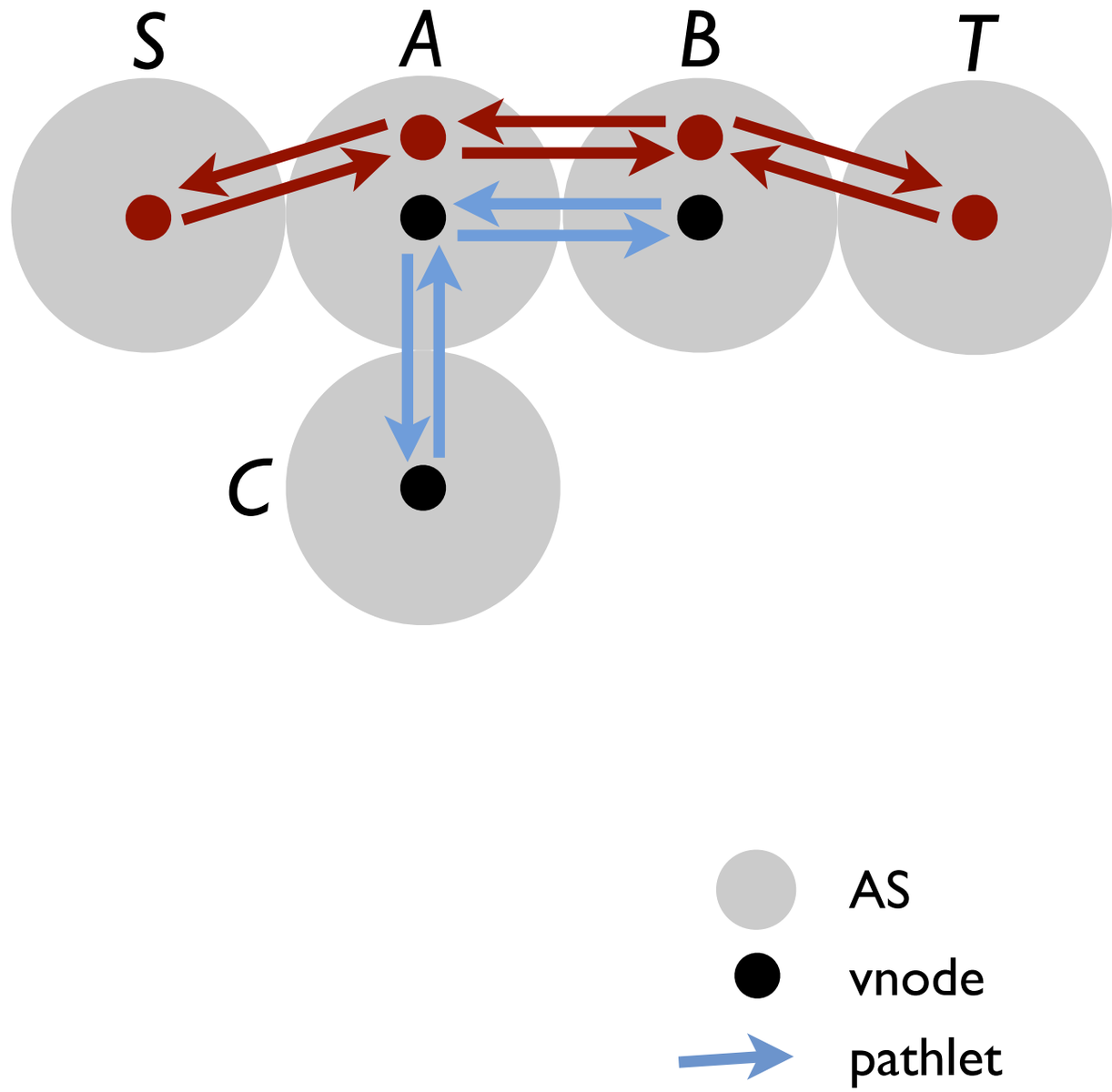
As usual in pathlet routing, this policy is enforced strongly in the data plane: there is no sequence of bits that *C* can put in a packet header that would cause it to arrive at *S* or *T*.

But we're glossing over one detail, dealing with what we call ingress vnodes. For example, *B* should be able to send to both of *A*'s vnodes, but *C* should only be able to send to the black one.

Ingress vnodes

Logically, *A* exposes a set of ingress vnodes to S and *B* (namely, the set is both of its vnodes), but *A* exposes only the black vnode to *C* because *C* is not permitted access to the VPN. When *B* sends *A* a packet, it tags the packet with the intended next-hop vnode. If *C* sends *A* a packet tagged with the red vnode, the packet is dropped.

At a high level, that's all there is to it. You can now stop reading unless you want the nitty-gritty details.

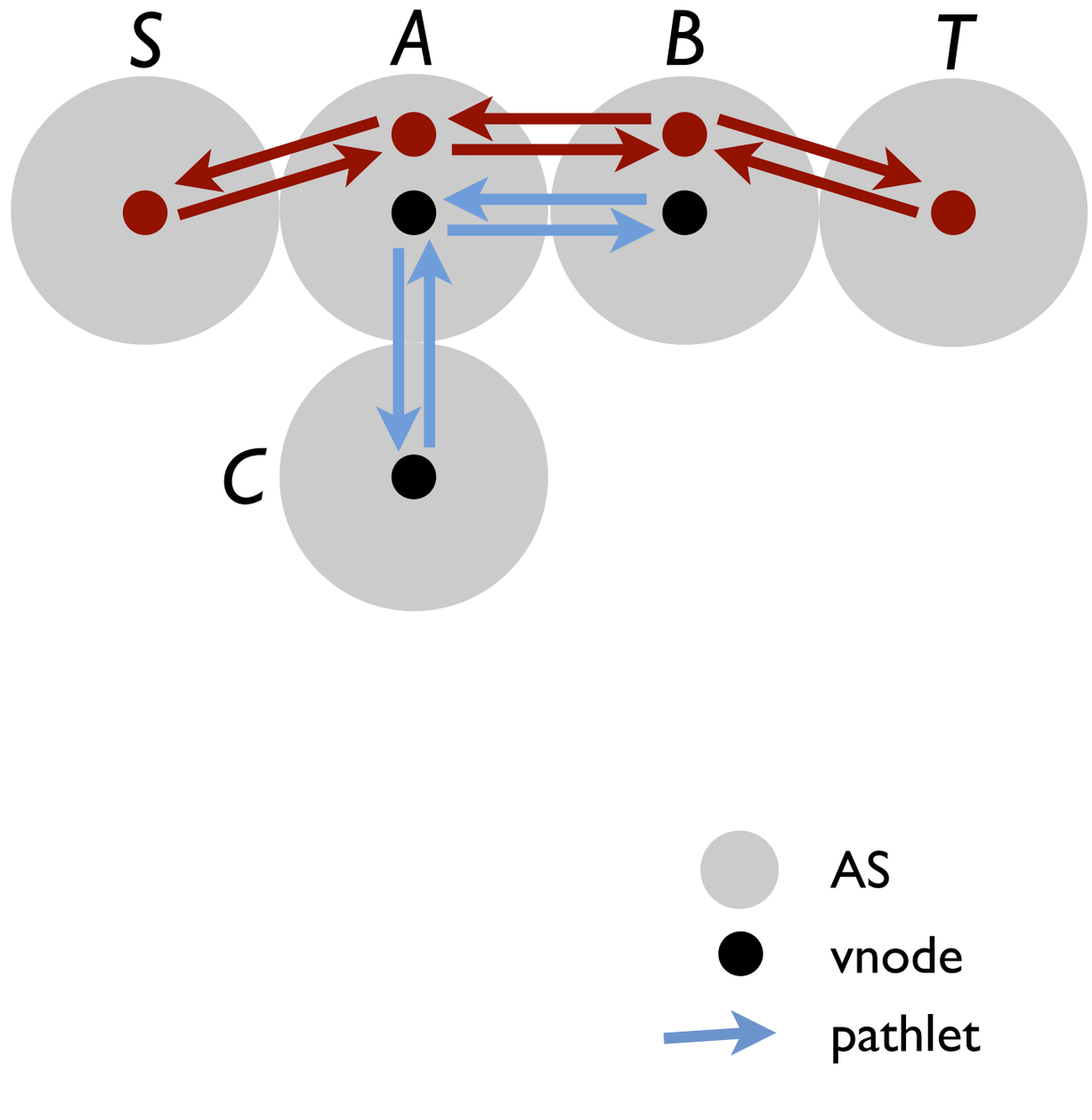


The details

The rest of this document is about the nitty-gritty details.

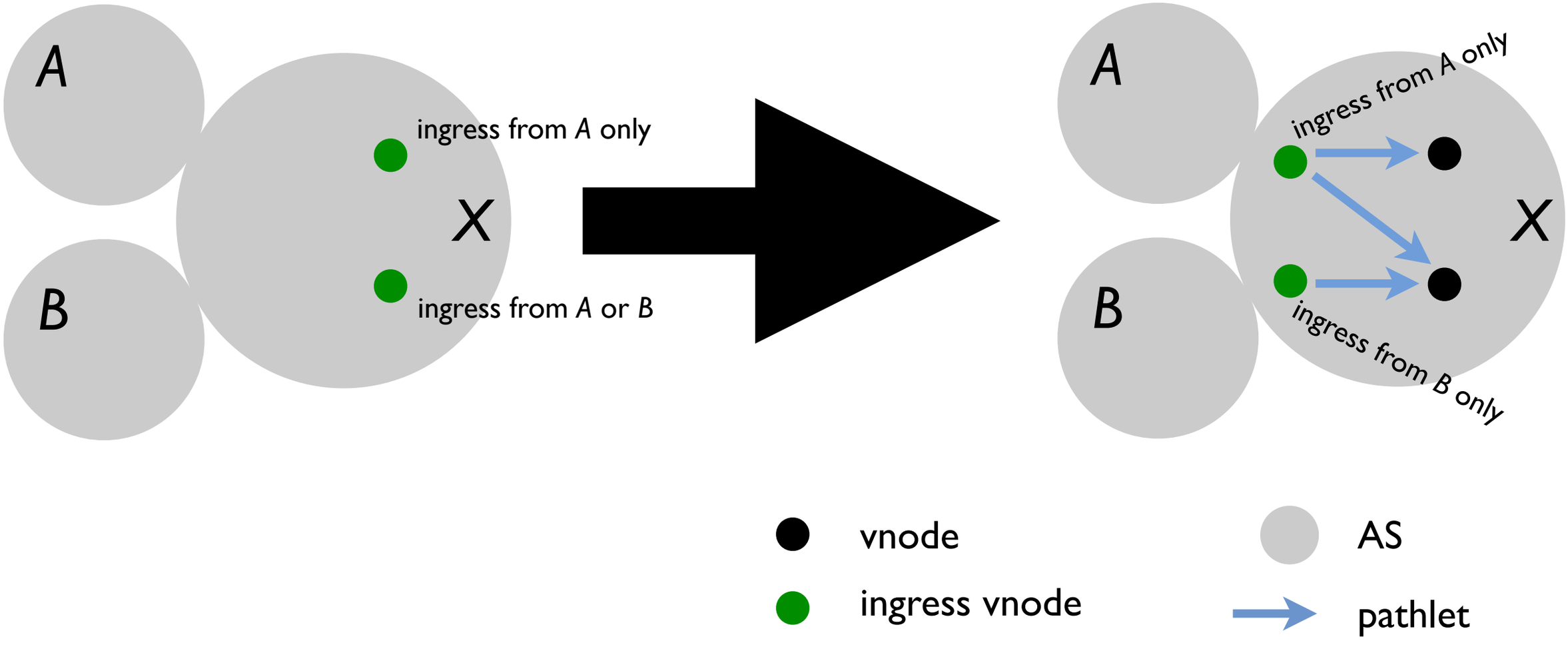
The issue is that tagging a packet with the intended vnode is slightly inconvenient. We felt it was cleaner to define the protocol so that packets contain only a list of pathlet identifiers (i.e., forwarding identifiers or FIDs). These are designed to be compact. Thus, the protocol spec in the paper says that a router specifies only a single ingress vnode for each neighbor.

Fortunately, it turns out that the single-ingress design is just as powerful as the set-of-ingress design, so the single-ingress protocol spec is fully capable of implementing VPNs. We take a look at this equivalence next.



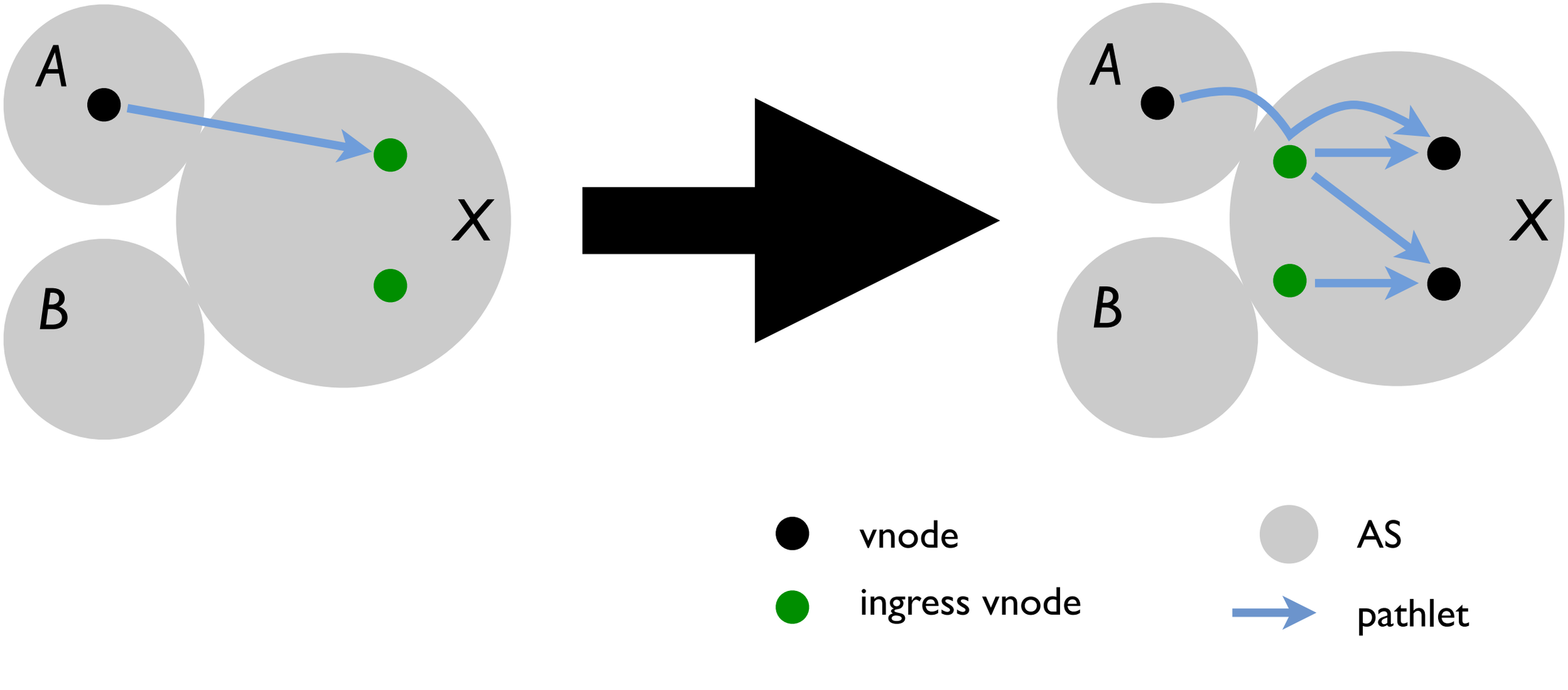
single ingress == multiple

It's easy to transform any multiple-ingress design to a single-ingress-per-neighbor design. We'll just show an example. Suppose *X* wants *A* to be able to ingress to both of *X*'s vnodes, but *B* should only ingress to one.



single ingress == multiple

One-hop pathlets into *X* are transformed into two-hop pathlets. Intuitively, instead of tagging a packet with its next-hop vnode, we're pushing another FID onto the front of the route.



VPN with one ingress

Putting it all together, here is a pathlet routing network which implements the desired VPN using only a single ingress vnode for each neighbor. The ingress vnode for a particular neighbor is, as you might expect, the one drawn closest to that neighbor.

This looks a bit complex, but in practice we would probably define the network as it looks in Slide 3 (which is more convenient for the operator) and then use the procedure of Slide 6-7 to automatically compile down to this single-ingress representation (which is more convenient for the data plane.)