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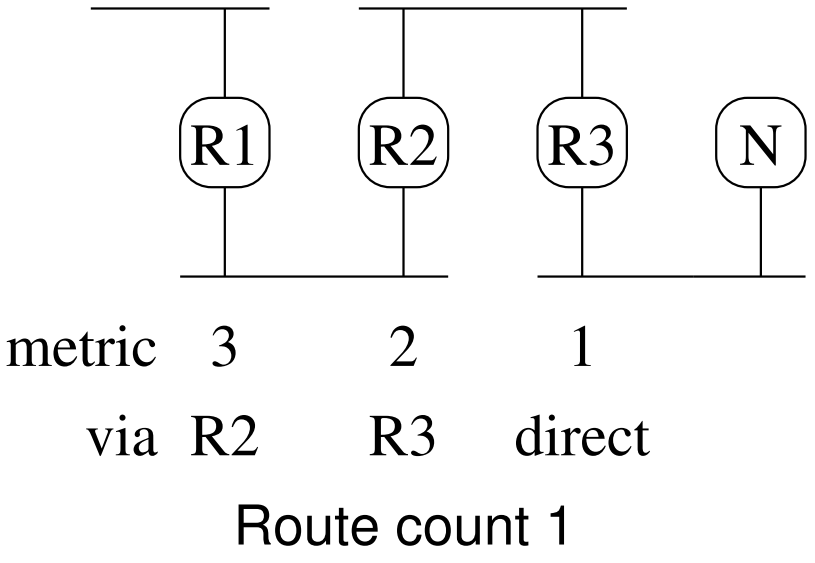
And this can manifest in bad ways

Routing

Slow Convergence

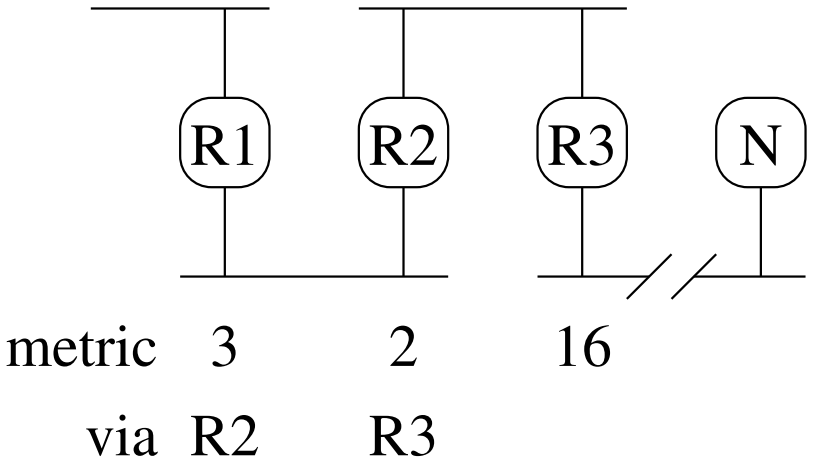


Route count 1

R3 knows a route to network N of hop count 1;

Routing

Slow Convergence

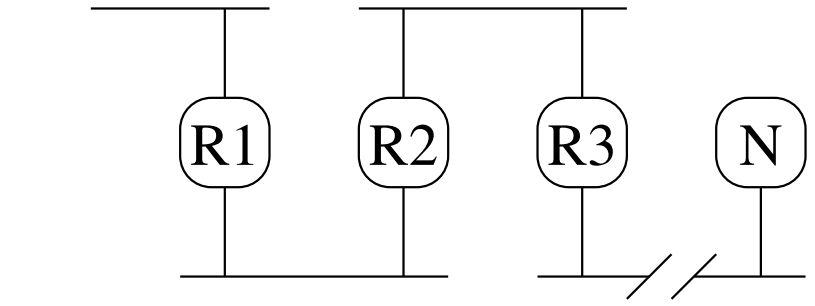


Break in route

After a break in the network R3 finds that route no longer works;

Routing

Slow Convergence

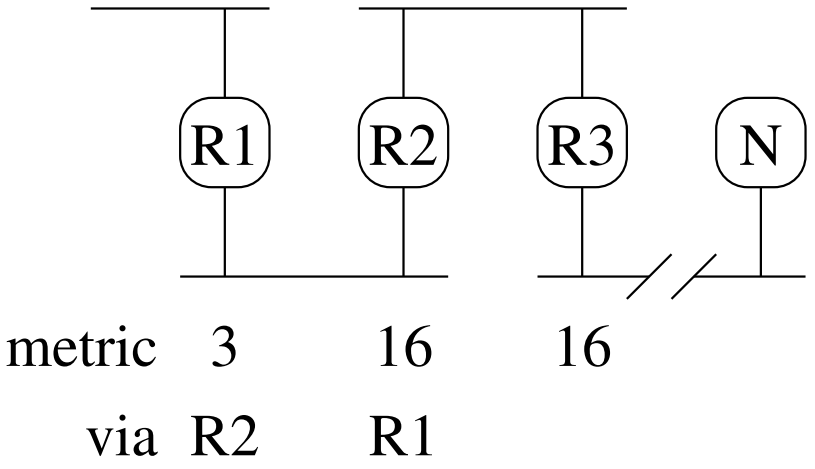


No route

So it sends a message to its neighbours (R2) saying “no route to N”. It uses a count of 16, which is interpreted as infinity;

Routing

Slow Convergence

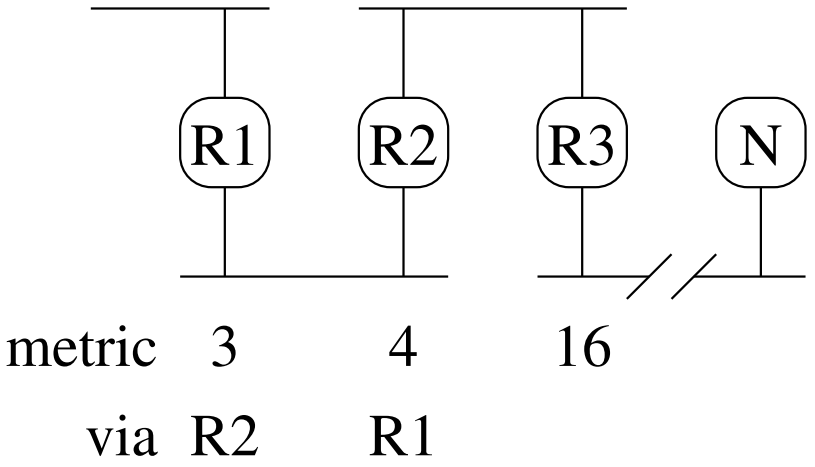


Update routing table

R2 updates its routing table;

Routing

Slow Convergence

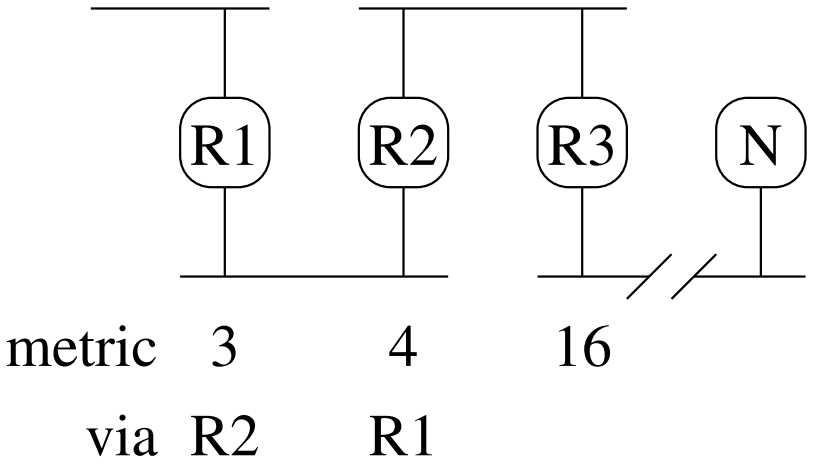


New route for R2?

But R2 also gets a periodic update message from R1 saying “route of 3 hops”;

Routing

Slow Convergence

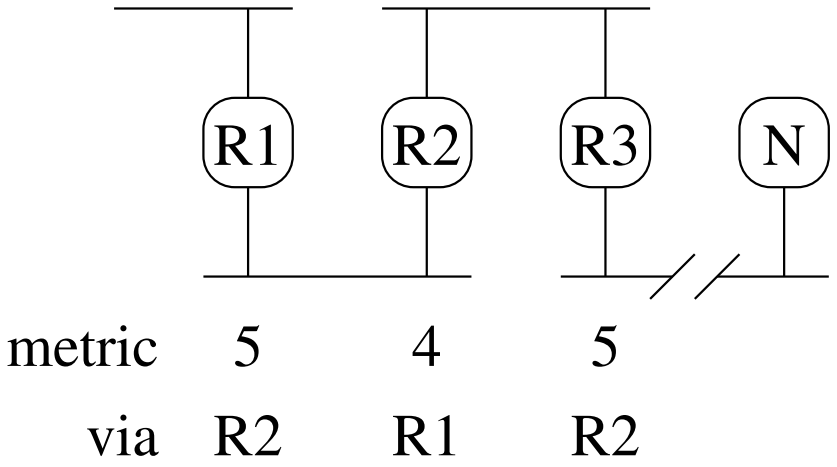


R2 update again

So R2 now thinks the best route is via R1, 4 hops;

Routing

Slow Convergence

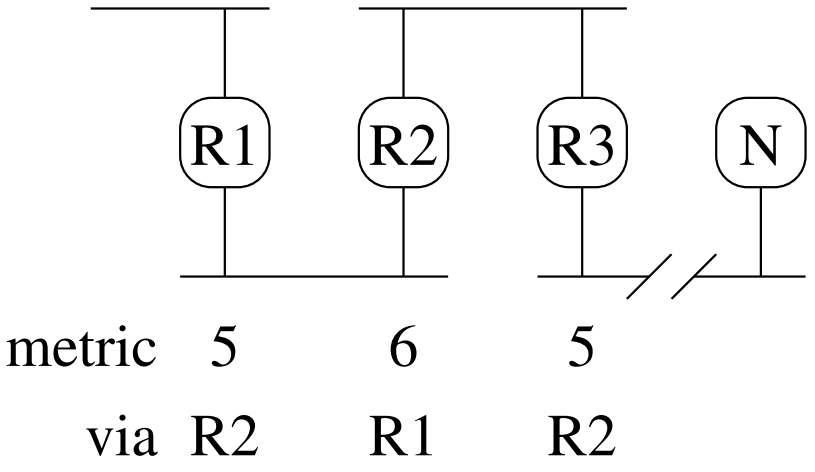


Another broadcast

And when R2 sends its periodic update message “4” to R1 and R3, R1 now thinks there is a route via R2 of 5 hops; and R3 thinks there is a route of 5 hops via R2;

Routing

Slow Convergence

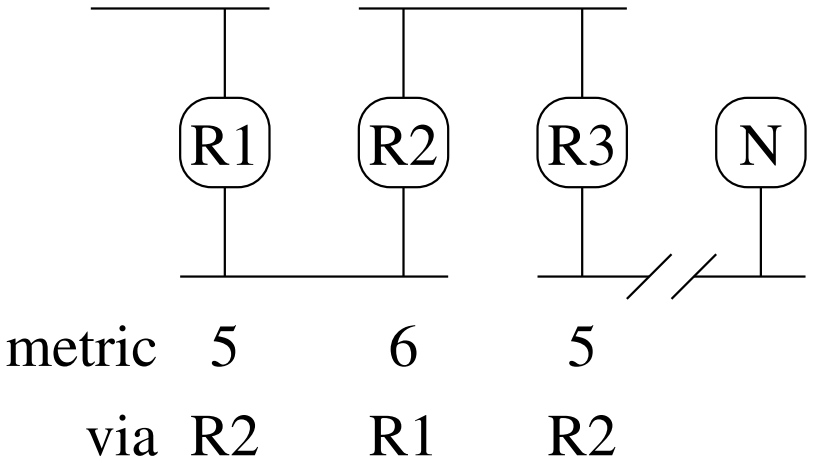


Counts grow slowly

After the next update, R2 thinks there is a route via R3 of 6 hops;

Routing

Slow Convergence

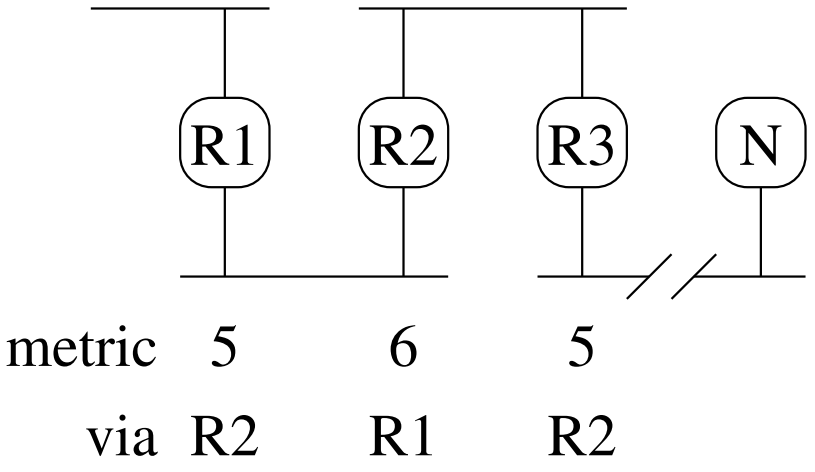


Counts grow slowly

And so on;

Routing

Slow Convergence

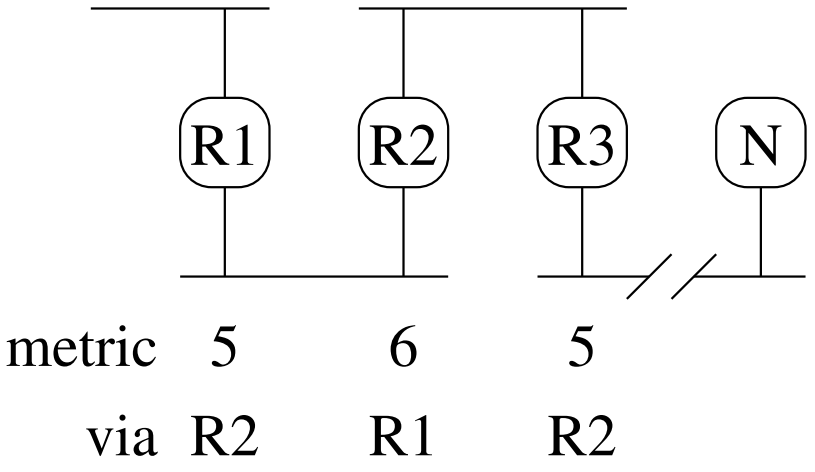


Counts grow slowly

Eventually the hop count reaches 16, i.e., no route, and so this route is dropped;

Routing

Slow Convergence

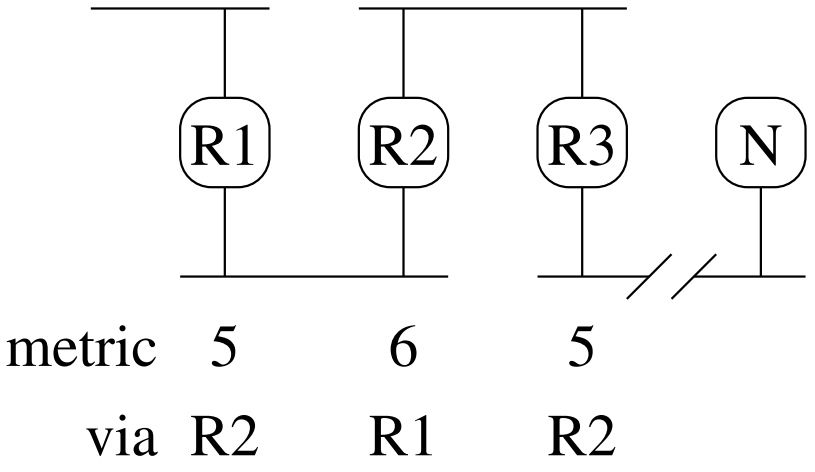


Counts grow slowly

This is called the *count to infinity* problem;

Routing

Slow Convergence



Counts grow slowly

If there was a valid route, it might take a long time to converge to that route

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Link state protocols, e.g., OSPF, converge faster, but need more complicated graph traversal algorithms to determine best routes

BGP

BGP is a *path vector* variation of distance vector: this includes the path (multiple hops) to the destination, which can be used to spot the loops that lead to count-to-infinity

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Exercise Read about path vector systems

BGP

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For example, it would be relatively easy to get BGP to transit data through an evil third party

Also, see the problem with the route to Youtube, earlier

BGP

Exercise Read about the 2018 hack on the cryptocurrency website `MyEtherWallet.com` that started by subverting BGP to send DNS traffic to a rogue server

Exercise Read about the BGP problem of April 2021, where Vodafone Idea (AS55410) published bad routes

Exercise Read about the proposed *Resource Public Key Infrastructure* (RPKI), RFC6810

Exercise Read about the *Mutually Agreed Norms for Routing Security* (MANRS) initiative for ISPs and routing exchange operators

BGP

Exercise Read about RIP

Exercise Read about Dijkstra's algorithm for finding shortest paths in a graph; and OSPF which uses this algorithm

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But the names are what makes things like the Web usable

Note we now have *three* kinds of addresses: physical, network and human

DNS

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Exercise The file lives on as `/etc/hosts` under Unix. Look at this file

DNS

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That is, machines running a DNS server program

Aside

In the usual way, when talking about these things, we blur the distinction between the service and the host it lives on. The host might well be running other services, such as DCHP, as well

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Exercise Find out the services your home Access Point runs

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`uk` is in the domain `.` (*dot* or *root*)

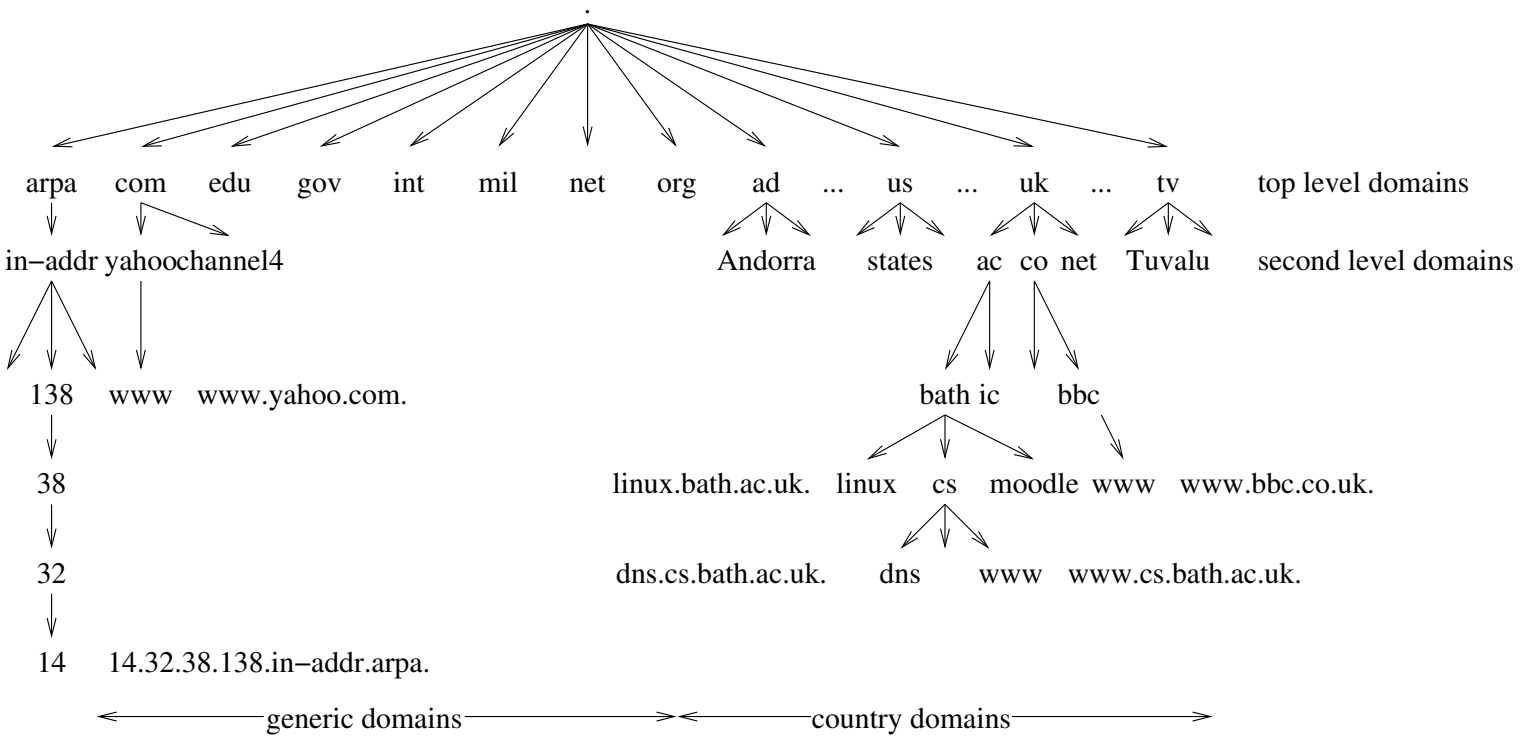
Each node in this tree is called a *label*

DNS

`www.llanfairpwllgwyngyllgogerychwyrndrobwllllantysiliogogogoch.com`
is a valid name

Labels may be up to 63 bytes long

DNS



The DNS hierarchy

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But the important bit is that they *delegate* management of lower labels to other organisations

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So, starting a dot, we can work our way down the tree to find the machine we want

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A few years ago, there was a convention of having an off-site replica, too, e.g., Bath used `ns2.ja.net`

DNS

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If a host on the Bath network needs to look up a local name, `linux.bath.ac.uk`, say, it sends a request to one of the local servers, e.g., `ns2.bath.ac.uk`

And the local server will look it up and return the answer

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Every host has the IP addresses of one or more local nameservers, typically in a file (e.g., `/etc/resolv.conf`) that was set up by an administrator or was created by DHCP (or SLAAC)

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So it can send the DNS request to one of these servers

DNS

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If a host in the University requires a name lookup of a non-local name, say `news.bbc.co.uk`, it sends a DNS request to the **local** DNS server, `ns1.bath.ac.uk`, say

DNS

In this example, the Bath server does not have responsibility for the name `news.bbc.co.uk`, but it will helpfully do a lookup for us. It will run down the DNS tree in a *recursive lookup*

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The Bath server `ns1` sends a *start of authority* (SOA) request to a random *top level* server to find who is responsible for the `uk` label

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This a machine that is responsible for `uk` labels

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It gets the IP address `194.130.56.40`

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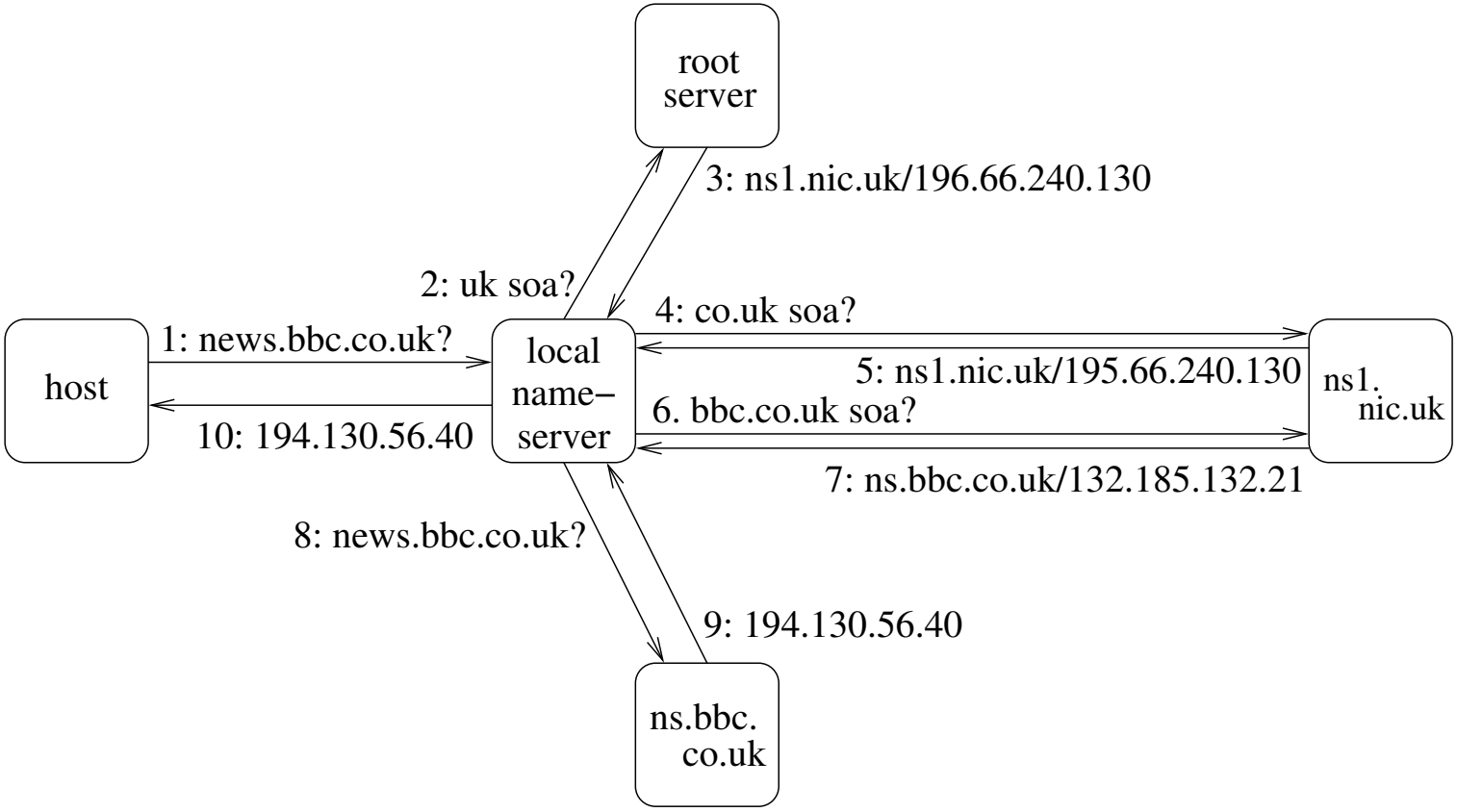
The server sends an *address* (A) request for `news.bbc.co.uk` to `ns.bbc.co.uk`

It gets the IP address `194.130.56.40`

Finally, the Bath server can relay this back to the original requesting host

DNS



DNS lookup

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Similarly, given a request for `www.bbc.co.uk`, it can go directly to `ns.bbc.co.uk`

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Short lived associations will have a short TTL

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And less work for the host