RPL

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RPL

- RPL stands for Routing Protocol for Low-power and Lossy Networks
- Layer 3 routing protocol.
- Every network must have a root node that originates the RPL DAG.

Enable RPL

- In the program:
  - **#include "net/rpl/rpl.h”**
- In the Makefile
  - **CFLAGS+= -DUIP_CONF_IPV6_RPL**
- For debugging or stats collection:
  - **CFLAGS+= -DRPL_CONF_STATS=1**

Initialize RPL

- Initialize a node as RPL ROOT node:

```
rpl_dag_t *dag;
dag = rpl_set_root(RPL_DEFAULT_INSTANCE,
                           (uip_ip6addr_t *)&ipaddr);
uip_ip6addr(&ipaddr, 0xaaaa, 0, 0, 0, 0, 0, 0, 0);
rpl_set_prefix(dag, &ipaddr, 64);
```

Right after network interface initialization

RPL global repair

- Root node can trigger RPL global repair:

```
rpl_repair_root(RPL_DEFAULT_INSTANCE);
```

Recall Trickle

- Each node maintains a counter c and a timer t in range [I/2, I] (at start, I = Imin)
- When a node receives metadata that is “consistent”, it increments c
- At time t, the node broadcasts a DIO message if c < K (redundancy threshold)
- When the interval I expires
  - I is doubled (up to Imax)
  - c is reset to zero
  - t is reset to a new value in the range [I/2, I]
- When a node receives a DIO message with metadata that is “inconsistent” I is reset to Imin (also c and t are reset)

Contiki Trickle

- All the RPL configuration parameters are in:
  - core/net/rpl/rpl-conf.h
- K = RPL_CONF_DIO_REDUNDANCY
- Imin = RPL_CONF_DIO_INTERVAL_MIN
  - $2^{\text{RPL\_CONF\_DIO\_INTERVAL\_MIN}}$
- Imax = RPL_CONF_DIO_INTERVAL_DOUBLINGS
  - $2^{(\text{RPL\_CONF\_DIO\_INTERVAL\_MIN} + \text{RPL\_CONF\_DIO\_INTERVAL\_DOUBLINGS})}$

Change trickle parameter

- Modify the project-conf.h file to set trickle parameters (see core/net/rpl/rpl-conf.h):

```
#undef RPL_CONF_DIO_REDUNDANCY
#define RPL_CONF_DIO_REDUNDANCY 1

#undef RPL_CONF_DIO_INTERVAL_MIN
#define RPL_CONF_DIO_INTERVAL_MIN 3

#undef RPL_CONF_DIO_INTERVAL_DOUBLINGS
#define RPL_CONF_DIO_INTERVAL_DOUBLINGS 5
```

Display RPL output

- To perform some analysis you must modify source file inside core/net/rpl/
- Set DEBUG DEBUG_PRINT in rpl-timers.c to investigate Trickle.
- Can also set custom '*printf*' in order to detect custom events.

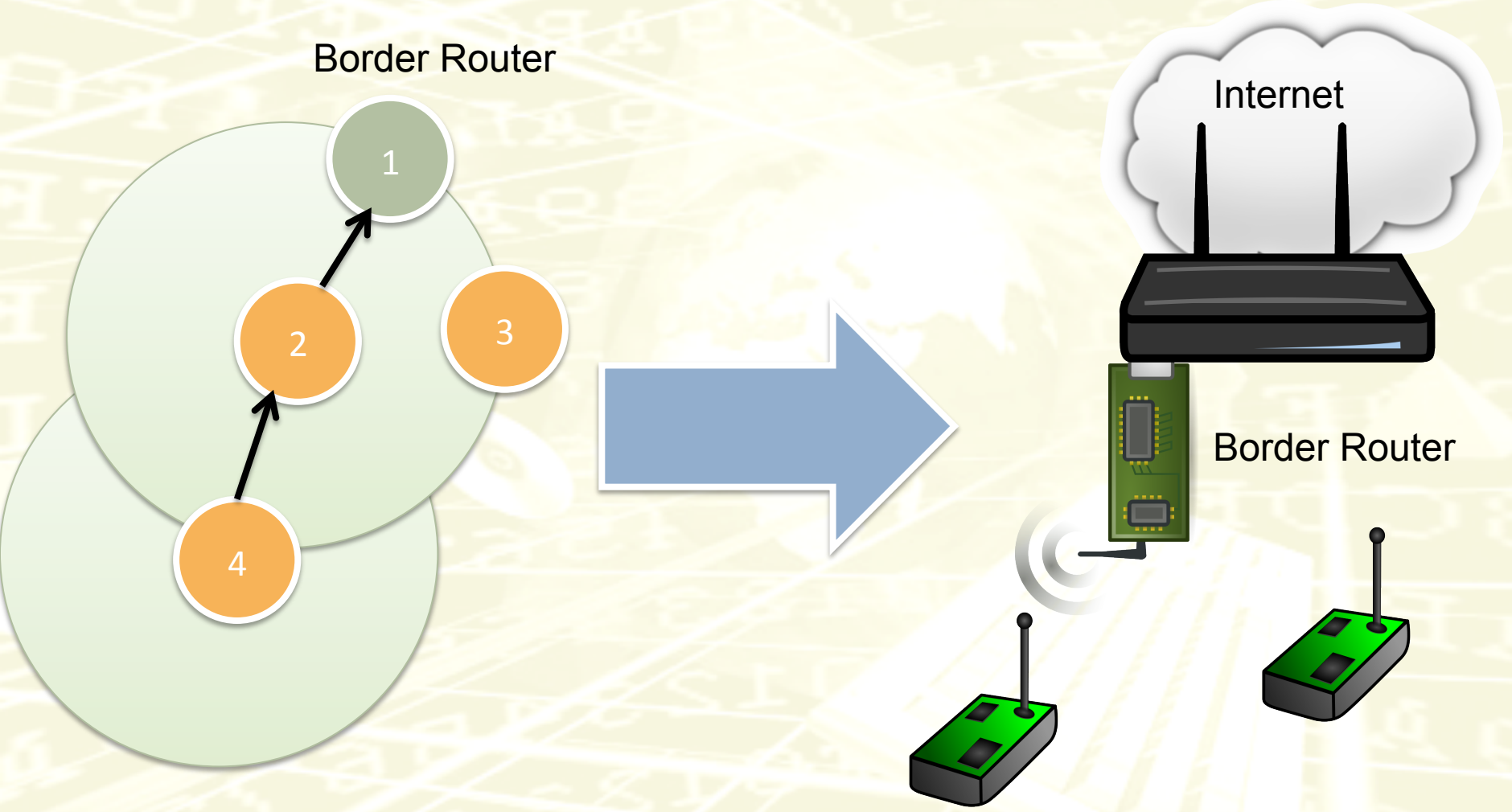
Do it!!

- Modify the examples *receiver.c* and *unicast-sender.c* from the previous lesson in order enable RPL (the receiver is the ROOT node).
- Change some RPL parameters and check the behaviour with wireshark or enabling the log in rpl-timers.c
- (opt) Modify the code of the root node in order to trigger the local repair procedure when the USR button of the mote is pressed.

RPL Border Router

- An RPL border router is used to:
  - Set the IPv6 global scope address of all motes.
  - Route messages from leafs to the root.
  - Interconnect a WSN to the rest of Internet.

Typical scenario



tunslip6

- The tunslip6 will create a virtual interface (called tun0) which is bridged to the border router.
- The interface will have an IPv6 address (aaaa::1).
- The border router will use the prefix (aaaa) as the global IPv6 prefix. This will be forwarder and installed in the overall WSN.

Set up on real motes

- Deploy a border router
  - examples/ipv6/rpl-border-router/border-router.c
- Use the tunslip6:
  - cd examples/ipv6/rpl-border-router/
  - Connect the mote to USB
  - make TARGET=z1 border-router.upload
  - make connect-router

BORDER ROUTER MUST BE CONNECTED TO /dev/ttyUSB0

Set up in cooja

Border Router has to be the first to be deployed!!

- Deploy a border router
  - examples/ipv6/rpl-border-router/border-router.c
- Add the socket on the border router
  - Tools -> Serial Socket (SERVER) -> Z1 1
- Deploy motes which will get the global IPv6 from the border router
- Use the tunslip6:
  - cd examples/ipv6/rpl-border-router/
  - make connect-router-cooja

Do it!!

- Set up a WSN with a border-router (which is also the RPL root node), an UDP Receiver and an UDP Sender.

- Try to ping all the motes:
  - E.g. ping6 aaaa::c30c:0:0:1