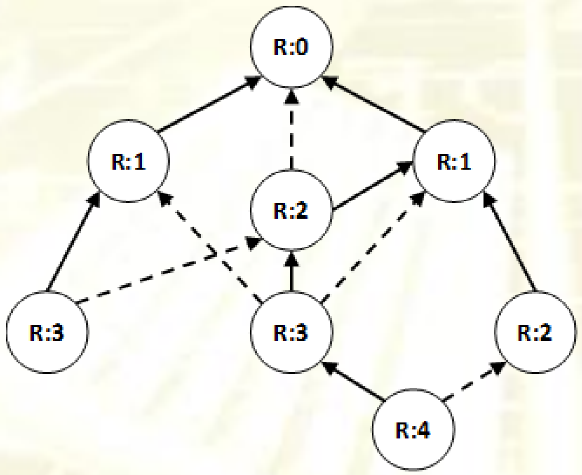
RPL

Carlo Vallati
Assistant Professor @ University of Pisa
c.vallati@iet.unipi.it

RPL

- RPL stands for Routing Protocol for Low-power and Lossy Networks
- It is a Layer 3 routing protocol aimed at building a Destination Oriented Directed Acyclic Graph
- Every network must have a root node that originates the RPL DAG
- Each node selects a set of neighbors as parent set
- A Preferred parent is selected for data forwarding



RPL - Messages

- *DODAG Information Object* (DIO) messages: broadcast by every node for upward route formation
- *DODAG Information Solicitation* (DIS) message: sent asynchronously to request routing information
- *DODAG Advertisement Object* (DAO) message: sent from nodes to root to form downward routes

Enable RPL in Contiki

- 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**

Enable RPL in Contiki

- In the project-conf.h:

```
#undef UIP_CONF_IPV6_RPL
#define UIP_CONF_IPV6_RPL 1
```

- RA protocol can be disabled (disabled by default):

```
#undef UIP_CONF_ND6_SEND_RA
#define UIP_CONF_ND6_SEND_RA 0
```

Initialize RPL

- In non-root nodes RPL is initialized automatically as the node starts
- In the RPL ROOT node RPL must be initialized explicitly to enable ROOT operations and include the network prefix to be advertized:

```
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

- RPL defines a procedure called *global repair*, which is invoked by the root node to reset all the routing information in the network and start over from a clean state
- Root node can trigger RPL global repair calling this function:

```
rpl_repair_root(RPL_DEFAULT_INSTANCE);
```

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).
- Modify the code of the root node in order to trigger the local repair procedure when the USR button of the mote is pressed.
- Check through wireshark the RPL messages, compare DIOs before and after the reset

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

- Trickle parameters can be modified in the project-conf.h file (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 obtain an insight on RPL operations the advanced debug can be enabled inside the single files within core/net/rpl/
- To investigate Trickle the DEBUG macro in in rpl-timers.c can be set to DEBUG_PRINT
- Custom '*printf*' can be added in order to track custom events

Do it!!

- Deploy a network in Cooja with many nodes and change some RPL parameters (e.g. se the redundancy threshold to 1)
- Check simulation logs to observe the behaviour of trickle in each node enabling the log of the file “rpl-timers.c”