生成树机制实验报告

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实验内容

- 基于已有代码，实现生成树运行机制，对于给定拓扑(four_node_ring.py)计算输出相应状态下的最小生成树拓扑。
- 构造一个不少于7个节点，冗余链路不少于2条的拓扑，节点和端口的命名规则可参考four_node_ring.py，使用stp程序计算输出最小生成树拓扑。

实验步骤

本次实验只需完成stp_handle_config_packet函数，即处理Config消息的功能。

1. 将收到的Config消息与本端口Config进行优先级比较

- Config之间的优先级比较遵循以下规则：
    - 如果两者认为的根节点ID不同，则根节点ID小的一方优先级高；
    - 如果两者到根节点的开销不同，则开销小的一方优先级高；
    - 如果两者到根节点的上一跳节点不同，则上一跳节点ID小的一方优先级高； 、如果两者到根节点的上一跳端口不同，则上一跳端口ID小的一方优先级高。
- 优先级比较函数如下：

```
int cmp_config_priority(stp_port_t *p, struct stp_config *config)
{
    // if config's priority > p's, return TRUE
    if (ntohll(config->root_id) != p->designated_root)
        return (ntohll(config->root_id) < p->designated_root) ? 1 : 0;
    else if (ntohl(config->root_path_cost) != p->designated_cost)
        return (ntohl(config->root_path_cost) < p->designated_cost) ? 1 : 0;
    else if (ntohll(config->switch_id) != p->designated_switch)
        return (ntohll(config->switch_id) < p->designated_switch) ? 1 : 0;
    else if (ntohs(config->port_id) != p->designated_port)
        return (ntohs(config->port_id) < p->designated_port) ? 1 : 0;
    return 0;
}
```

2. 收到的Config优先级高的情况处理

如果收到的Config优先级高，说明该网段通过对方端口连接根节点开销更小，则进行以下操作：

- 将本端口的Config替换为收到的Config消息，本端口为非指定端口；

- 更新节点状态(①)，更新剩余端口的Config(②)；

    - ①更新结点状态

        - 遍历所有端口，满足如下条件的为根端口(root_port)
            - 该端口是非指定端口
            - 该端口的优先级要高于所有剩余非指定端口
        - 如果不存在根端口，则该节点为根节点。
        - 否则，选择通过root_port连接到根节点，更新节点状态。
        - 代码如下：

```
// update stp state
    stp->root_port = NULL;
    for (int i = 0; i < stp->nports; i ++) {
            if (stp_port_is_designated(&stp->ports[i]))
                    continue;
            if ( stp->root_port == NULL || (stp->root_port != NULL \
                 && cmp_port_priority(&stp->ports[i], stp->root_port) > 0))
                    stp->root_port = &stp->ports[i];
    }
    if (stp->root_port == NULL) {
            // cannot find desire root port
            stp->designated_root = stp->switch_id;
            stp->root_path_cost = 0;
    } else {
            stp->designated_root = stp->root_port->designated_root;
            stp->root_path_cost = stp->root_port->designated_cost + stp->root_port->path_cost;
    }
```

- ②更新剩余端口的Config
    - 如果一个端口为非指定端口，且其网段通过本节点到根节点的开销比通过对端节点的开销小，那么该端口成为指定端口。
    - 对于所有指定端口，更新其认为的根节点和路径开销。
    - 代码如下：

```
// update rest config
    stp_port_t * port_i;
    for (int i = 0; i < stp->nports; i ++) {
            port_i = &stp->ports[i];
            if (port_i == p) continue;
            if (stp_port_is_designated(port_i)) {
                    port_i->designated_root = stp->designated_root;
                    port_i->designated_cost = stp->root_path_cost;
            } else {
                    if (stp->root_path_cost < port_i->designated_cost) {
                            port_i->designated_switch = stp->switch_id;
                            port_i->designated_port = p->port_id;
                    }
            }
    }
```

- 如果节点由根节点变为非根节点，停止hello定时器；
    - 初始情况下均为根节点，如果某端口遇到更优的config信息，就说明它一定不是根节点，所以只要比较得出config优先级高，则停掉hello计时器。
- 将更新后的Config从每个指定端口转发出去。

3. 本端口Config优先级高的情况处理

- 如果本端口Config优先级高，说明该网段通过本端口连接根节点开销更小，该端口是指定端口，发送Config消息。

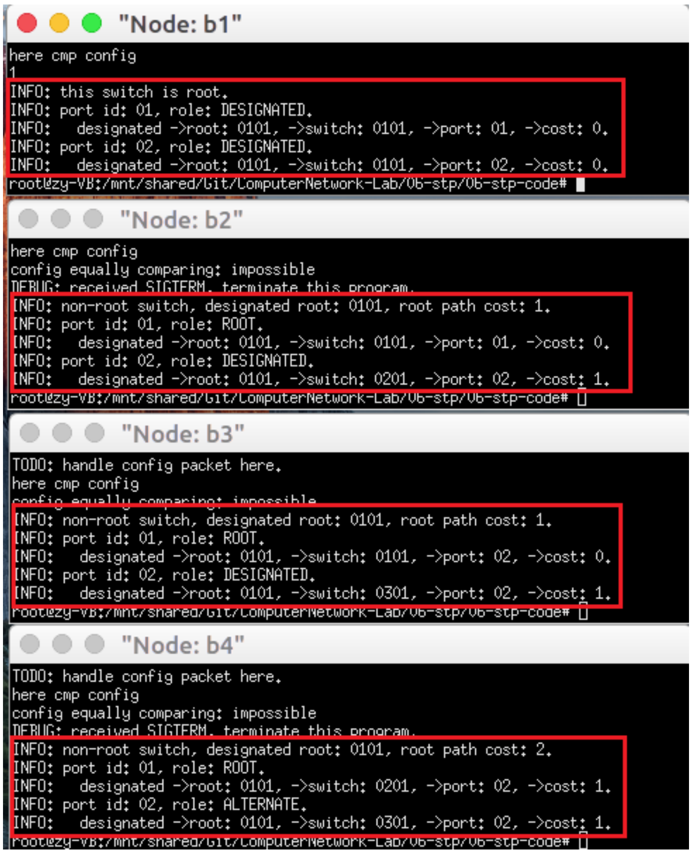
4. 完整stp_handle_config_packet函数

```
static void stp_handle_config_packet(stp_t *stp, stp_port_t *p, struct stp_config *config)
{
    // TODO: handle config packet here
    // fprintf(stdout, "TODO: handle config packet here.\n");

    // compare priority of configs
    if (cmp_config_priority(p, config)) {
        // replace config
        p->designated_root = ntohll(config->root_id);
        p->designated_port = ntohs(config->port_id);
        p->designated_cost = ntohl(config->root_path_cost);
        p->designated_switch = ntohll(config->switch_id);

        // update stp state
        stp->root_port = NULL;
        for (int i = 0; i < stp->nports; i ++) {
            if (stp_port_is_designated(&stp->ports[i]))
                continue;
            if ( stp->root_port == NULL || (stp->root_port != NULL \
                && cmp_port_priority(&stp->ports[i], stp->root_port) > 0))
                stp->root_port = &stp->ports[i];
        }
        if (stp->root_port == NULL) {
            // cannot find desire root port
            stp->designated_root = stp->switch_id;
            stp->root_path_cost = 0;
        } else {
            stp->designated_root = stp->root_port->designated_root;
            stp->root_path_cost = stp->root_port->designated_cost + stp->root_port->path_cost;
        }

        // update rest config
        stp_port_t * port_i;
        for (int i = 0; i < stp->nports; i ++) {
            port_i = &stp->ports[i];
            if (port_i == p) continue;
            if (stp_port_is_designated(port_i)) {
                port_i->designated_root = stp->designated_root;
                port_i->designated_cost = stp->root_path_cost;
            } else {
                if (stp->root_path_cost < port_i->designated_cost) {
                    port_i->designated_switch = stp->switch_id;
                    port_i->designated_port = p->port_id;
                }
            }
        }
        // stop hello timer
        stp_stop_timer(&stp->hello_timer);

        // send new config from designated port
        stp_send_config(stp);

    } else {
        stp_port_send_config(p);
    }
}
```

实验结果

1. 利用四结点环路验证STP函数

验证结果如下：



```
here cmp config
1
INFO: this switch is root.
INFO: port id: 01, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code#
```

```
here cmp config
config equally comparing: impossible
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code#
```

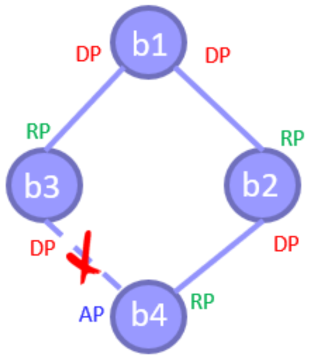
```
TODO: handle config packet here.
here cmp config
config equally comparing: impossible
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0301, ->port: 02, ->cost: 1.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code#
```

```
TODO: handle config packet here.
here cmp config
config equally comparing: impossible
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 2.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0301, ->port: 02, ->cost: 1.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code#
```

```
# ./dump_output.sh 4
NODE b1 dumps:
INFO: this switch is root.
INFO: port id: 01, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.

NODE b2 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
```

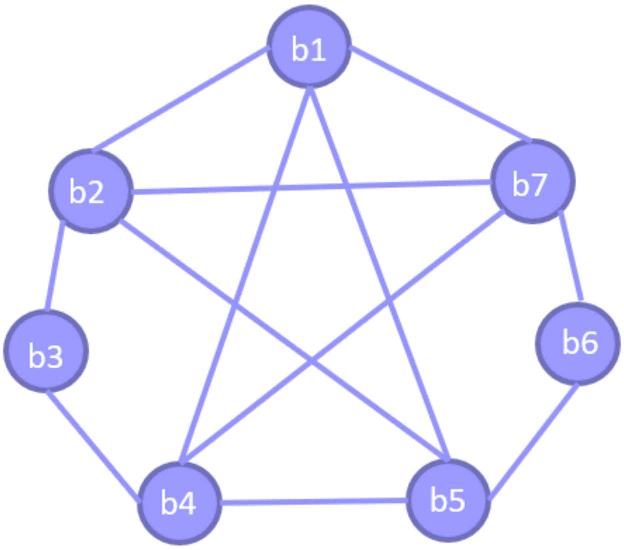
```
INFO: port id: 02, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.

NODE b3 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0301, ->port: 02, ->cost: 1.

NODE b4 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 2.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0301, ->port: 02, ->cost: 1.
```

得到课件中的网络结构：

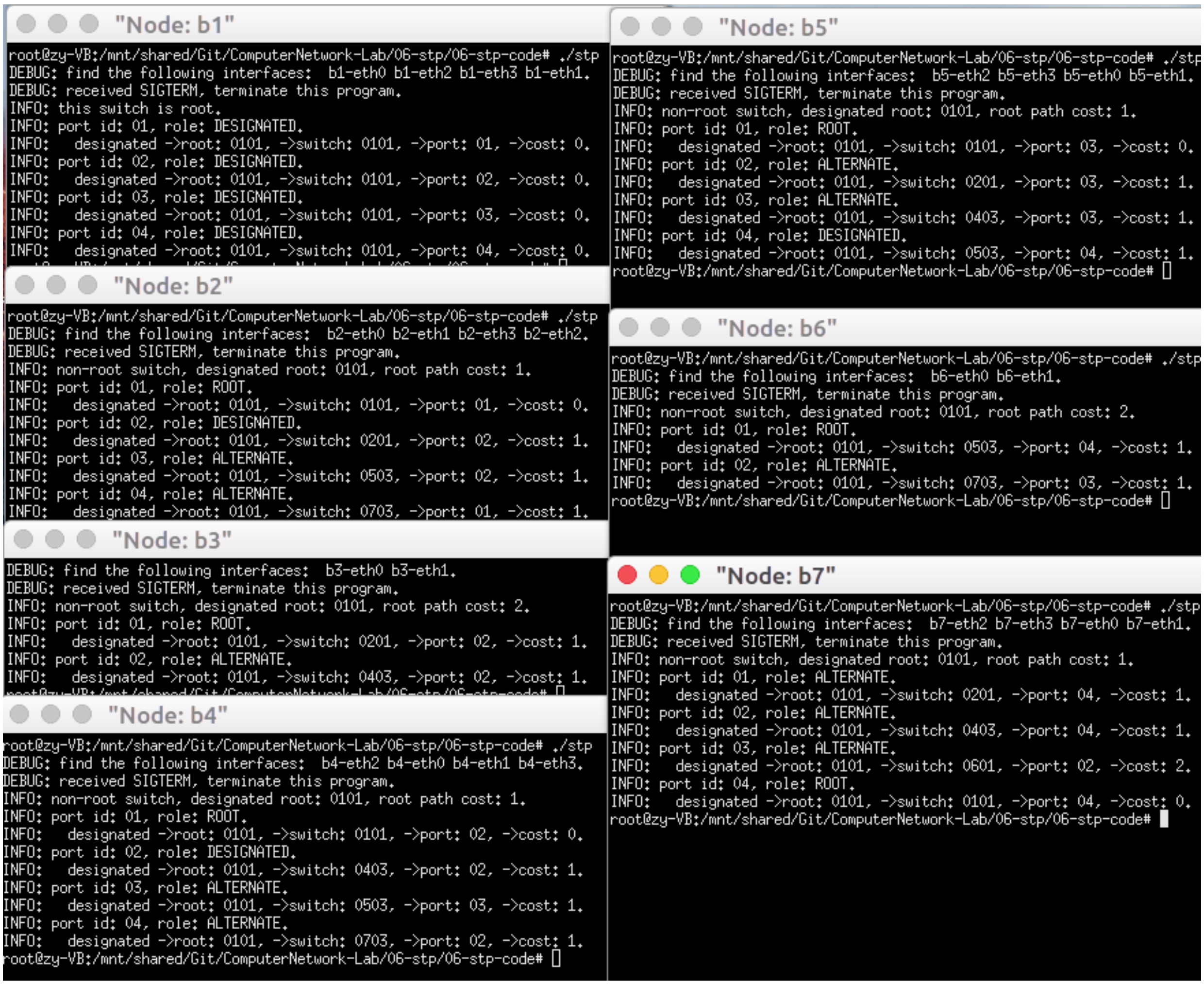


2. 构造七结点网络拓扑验证STP函数

构造的七结点拓扑结构如下图(代码见`seven_node_topo.py`文件)：



运行生成树函数的结果：



```
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# ./stp
DEBUG: find the following interfaces:  b1-eth0 b1-eth2 b1-eth3 b1-eth1.
DEBUG: received SIGTERM, terminate this program.
INFO: this switch is root.
INFO: port id: 01, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
INFO: port id: 03, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 03, ->cost: 0.
INFO: port id: 04, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 04, ->cost: 0.
```

```
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# ./stp
DEBUG: find the following interfaces:  b2-eth0 b2-eth1 b2-eth3 b2-eth2.
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
INFO: port id: 03, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0503, ->port: 02, ->cost: 1.
INFO: port id: 04, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0703, ->port: 01, ->cost: 1.
```

```
DEBUG: find the following interfaces:  b3-eth0 b3-eth1.
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 2.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0403, ->port: 02, ->cost: 1.
```

```
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# ./stp
DEBUG: find the following interfaces:  b4-eth2 b4-eth0 b4-eth1 b4-eth3.
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0403, ->port: 02, ->cost: 1.
INFO: port id: 03, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0503, ->port: 03, ->cost: 1.
INFO: port id: 04, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0703, ->port: 02, ->cost: 1.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# 
```

```
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# ./stp
DEBUG: find the following interfaces:  b5-eth2 b5-eth3 b5-eth0 b5-eth1.
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 03, ->cost: 0.
INFO: port id: 02, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0201, ->port: 03, ->cost: 1.
INFO: port id: 03, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0403, ->port: 03, ->cost: 1.
INFO: port id: 04, role: DESIGNATED.
INFO:   designated ->root: 0101, ->switch: 0503, ->port: 04, ->cost: 1.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# 
```

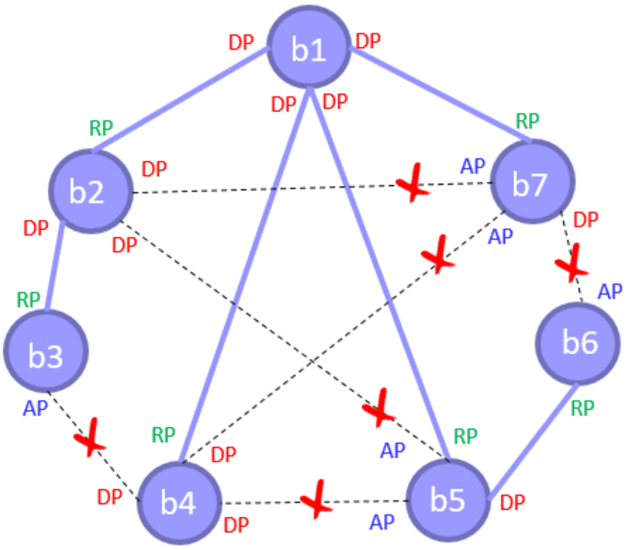
```
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# ./stp
DEBUG: find the following interfaces:  b6-eth0 b6-eth1.
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 2.
INFO: port id: 01, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0503, ->port: 04, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0703, ->port: 03, ->cost: 1.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# 
```

```
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# ./stp
DEBUG: find the following interfaces:  b7-eth2 b7-eth3 b7-eth0 b7-eth1.
DEBUG: received SIGTERM, terminate this program.
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0201, ->port: 04, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0403, ->port: 04, ->cost: 1.
INFO: port id: 03, role: ALTERNATE.
INFO:   designated ->root: 0101, ->switch: 0601, ->port: 02, ->cost: 2.
INFO: port id: 04, role: ROOT.
INFO:   designated ->root: 0101, ->switch: 0101, ->port: 04, ->cost: 0.
root@zy-VB:/mnt/shared/Git/ComputerNetwork-Lab/06-stp/06-stp-code# 
```

```
# ./dump_output.sh 7
NODE b1 dumps:
INFO: this switch is root.
INFO: port id: 01, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
INFO: port id: 03, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 03, ->cost: 0.
INFO: port id: 04, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 04, ->cost: 0.

NODE b2 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 01, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
INFO: port id: 03, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 03, ->cost: 1.
INFO: port id: 04, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 04, ->cost: 1.

NODE b3 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 2.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 02, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0403, ->port: 02, ->cost: 1.

NODE b4 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 02, ->cost: 0.
INFO: port id: 02, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0403, ->port: 02, ->cost: 1.
INFO: port id: 03, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0403, ->port: 03, ->cost: 1.
```

```
INFO: port id: 04, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0403, ->port: 04, ->cost: 1.

NODE b5 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 03, ->cost: 0.
INFO: port id: 02, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 03, ->cost: 1.
INFO: port id: 03, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0403, ->port: 03, ->cost: 1.
INFO: port id: 04, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0503, ->port: 04, ->cost: 1.

NODE b6 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 2.
INFO: port id: 01, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0503, ->port: 04, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0703, ->port: 03, ->cost: 1.

NODE b7 dumps:
INFO: non-root switch, designated root: 0101, root path cost: 1.
INFO: port id: 01, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0201, ->port: 04, ->cost: 1.
INFO: port id: 02, role: ALTERNATE.
INFO:       designated ->root: 0101, ->switch: 0403, ->port: 04, ->cost: 1.
INFO: port id: 03, role: DESIGNATED.
INFO:       designated ->root: 0101, ->switch: 0703, ->port: 03, ->cost: 1.
INFO: port id: 04, role: ROOT.
INFO:       designated ->root: 0101, ->switch: 0101, ->port: 04, ->cost: 0.
```

所构造的开销最小的树状拓扑如下：



结果分析

根据上图的检验，可见生成的网络结构为树状，且没有冗余环路，结果正确。
生成树算法确实可以从逻辑上避免环路，避免广播风暴。