Ethernet Cable Diagnostics using Netlink Ethtool API

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THAT'S JUST NUTS!

Pesky squirrels gnawing through superfast BT broadband cables in woodland because they taste of nuts
Structured Wiring: Where is the Fault?

- PC to wall patch cable?
- In the wall?
- Closet patch cable?
Predict the Fault Before it Happens

- Twisting, bending, vibration, water ingress, etc, can degrade and eventually break a cable or its connectors.
- The diagnostics don’t need to be binary good/bad.
Ethernet Cables

- Two (10/100Mbps) or four (1Gbps-10Gbps), twisted pairs.
- Pair and Twist gives good immunity to cross talk and emissions/induction.
Differential Pair

- Transmit opposites on the pair
- Cable acts like a radio antenna
- Both cables pick up about the same noise signal
- Receiver subtracts out the noise
1687: Sir Isaac Newton and the Speed of Sound

- Newton measured the speed of sound by timing the echo of a clap, over a known distance.
- Maybe the beginning of Time-Domain Reflectometry, TDR.

https://mountainmystery.files.wordpress.com
Cables and TDR

- The same principle works for an electrical pulse sent down a cable.
- Moves down the cable at about 280*10^6 m/s.
- The pulse is reflected by changes in impedance in the cable.
- Measure the time of the reflect, derive the distance.
Open Ended Pair
Shorted Pair
Break in one cable
Everything O.K.
Problems Plumbing this into Linux

- No two PHYs are the same
  - Different fault codes
  - First fault vs 4 faults
  - Raw TDR data
  - 1, 2 or 4 pairs
  - Pulse configuration

- Does not fit well into an ethtool IOCTL call
Challenges

- Slow, a few seconds to run diagnostics
  - `ethtool` holds the RTNL while calling driver
  - Not acceptable to hold RTNL this long
  - Possible race conditions if we don’t hold RTNL
  - `ethtool` IOCTL has no async mechanism
Netlink Ethtool

• Michal Kubecek <mkubecek@suse.cz>

• This is first part of netlink based alternative userspace interface for ethtool. The aim is to address some long known issues with the ioctl interface, mainly lack of extensibility, raciness, limited error reporting and absence of notifications. The goal is to allow userspace ethtool utility to provide all features it currently does but without using the ioctl interface.
NL ethtool provides the missing Pieces

- Netlink ethtool
  - Flexible selection of result attributes
  - RTNL held during get/set
  - Spontaneous notification messages to user space
    - Trigger diagnostics using set
    - Report results later, spontaneously

- Still some potential for race conditions
PHY State Machine
Flow

- ETHNL_CMD_ACT_CABLE_TEST
  - Start Cable test
  - Allocate SKB for results
  - Change to PHY_CABLETEST state
  - Return via ETHNL O.K

- Poll PHY/wait for interrupt until test complete
  - PHY uses helpers to fill SKB with results
  - Core multicasts ETHTOOL_A_EVENT_CABLE_TEST with results
  - Change to PHY_UP state to restart auto-neg, etc.
Driver API

struct phy_driver {
    ...
    /* Start a cable test */
    int (*cable_test_start)(struct phy_device *dev, int options);

    /* Once per second, or on interrupt, request the status of the test.
    */
    int (*cable_test_get_status)(struct phy_device *dev, bool *finished);
}

int phy_cable_test_result(struct phy_device *phydev, u8 pair, u16 result);
int phy_cable_test_fault_length(struct phy_device *phydev, u8 pair, u16 cm);
int phy_cable_test_amplitude(struct phy_device *phydev, int distance, u8 pair, int mV);
int phy_cable_test_pulse(struct phy_device *phydev, int mV);
Ethtool(1) support

./ethtool --cable-test lan6
Cable test for device lan6.
Pair: 0, result: OK
Pair: 1, result: OK
Pair: 2, result: OK
Pair: 3, result: OK

./ethtool --cable-test lan2
Cable test for device lan2.
Pair: 0, result: Open Circuit
Pair: 1, result: Open Circuit
Pair: 2, result: Open Circuit
Pair: 3, result: Open Circuit
Pair: 0, fault length: 14.40m
Pair: 1, fault length: 15.20m
Pair: 2, fault length: 14.40m
Pair: 3, fault length: 15.20m

./ethtool --cable-test lan5
Cable test for device lan5.
Pair: 0, result: OK
Pair: 1, result: OK
Pair: 2, result: Short within Pair
Pair: 3, result: Short within Pair
Pair: 2, fault length: 1.60m
Pair: 3, fault length: 0.80m
Ethtool(1) – Raw TDR data

```
./ethtool --cable-test lan2 amplitude-graph
Cable test for device lan2.
Cable test Pulse: 1000mV
```

<table>
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<th>Pair 0</th>
<th>Pair 1</th>
<th>Pair 2</th>
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Graph shows reflection amplitude in mV vs distance in m.
Status

- Waiting for Ethtool Netlink to be merged
- Code posted once for review
- Marvell 1G PHY driver supported
- Planned: 10G Marvell & Aquantia PHY drivers
- Microchip will add support
- Broadcom will likely add support