TOSHIBA

2019 CIP MINI SUMMIT

Use Case of CIP for Power Plant Systems

Toshiba Energy Systems & Solutions Corporation

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Self-introduction

My Background & experience

- Embedded software engineer (RTOS)
- Linux controller development lead
- Development Group manager
- Development chief specialist
  - Embedded software, Hardware, FPGA, Web-based software

Introduction of my company & department

- Toshiba Energy Systems & Solutions
  - provides energy-related systems
  - renewable energy, power distribution and VPP
  - hydrogen, nuclear and thermal

- Power Platform Development Department
  - Product development and supply to support power infrastructure worldwide

Purpose of This Presentation

For whom

→ People who are using and will use Linux for high reliable embedded products

How to be

→ Join and be part of CIP

Approach

→ What cases we have experienced and CIP effectiveness

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Contents

Product Introduction

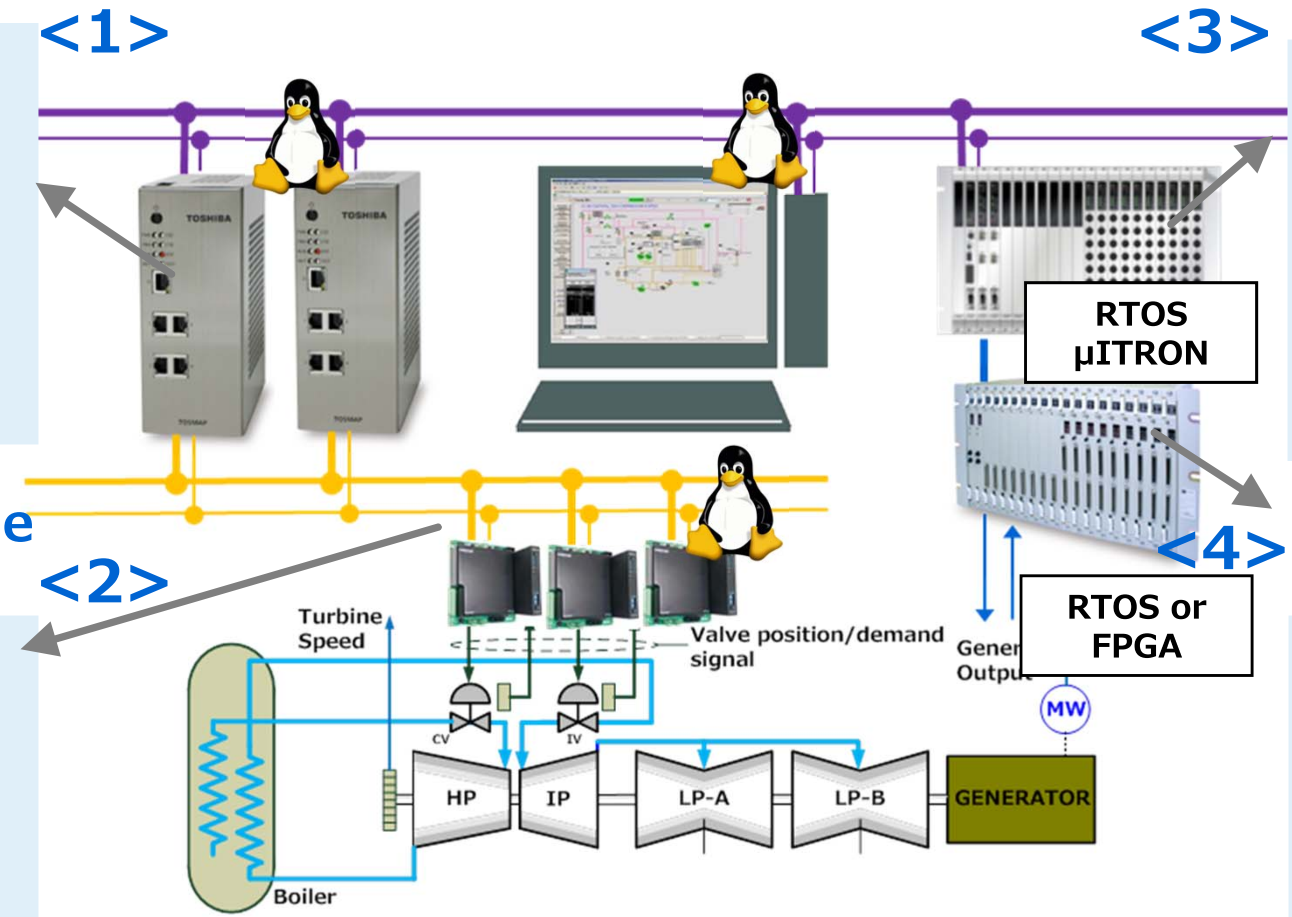
Four major product groups based on target and cycle

DCS controller

100 ms & more control. It performs boiler control, monitoring throughout plant.

Control module for generator

0.5 to 3 ms control. It performs I/O of generator signals and conducts high-speed control.



Control module for turbine

3 to 10 ms control. It performs valve control, frequency detection and speed detection exclusively.

I/O control module

Module for DI/DO/AI/AO and to control them. It is generally used for monitoring & control in power plant.

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Product Introduction – Features

Products are equipped with rigorous features for stable supply of electricity.

1 Realization of high availability with redundancy

- Machine & transmission path are all redundant.
- Triplex redundancy for important turbine control
- Continuous control realized by real-time switching

2 Long-term supply & maintenance

- Over 10 years of monitoring & control with the same product
- Continuous supply of hardware & software
- Response to revised/abolished hardware

3 Prompt response to abnormality & accountability

- Log function to overcome two conflicting problems; analysis is allowed without affecting real-time control.
- Differentiation between single failure and common cause failure
- Evidence-based report

4 Secured & safe device

- Evaluation and measures for vulnerability
- Patch application with maintaining reliability
- Application of the latest features such as whitelist
- Differentiation between failure and attack

Despite these constraints, we decided to apply Linux for more enhanced functionality and speedy developments

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Product Introduction - history of our controllers

Before Products based on real-time OS & self-made µITRON

After Linux-based controllers

Self-made OS

Self-made RTOS µITRON

Linux rt

CIP rt Linux

CIVIL INFRASTRUCTURE PLATFORM

Closed self-reliance management:
Software, drivers and hardware
are all internally prepared.

Departure from closed self-reliance management
OSS utilization for other than core portions

CIP 4.4rt

1990～ 2000～ 2010～ 2020～

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Product Introduction – Application of Linux

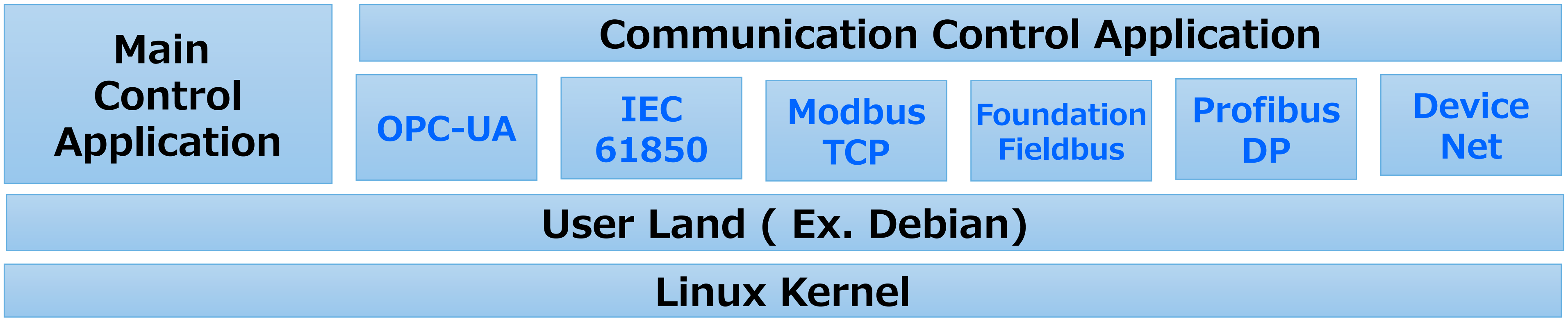
Why Linux?

- Various open protocol
- Easy to use hardware
- Utilization of stack from 3rd vendors
- Similar operation on PC

→ speedy value-added products launch

Overview of systems we have developed

- Development efficiency and speed improved by utilizing various OSS and 3rd party vendor software; benefits and advantages provided



However, some issues have emerged

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Issues after Linux Application

Kernel correction cases

1. Problems in kernel/driver (all low-frequency)
   a. Kernel panic with e1000 (network) driver
   b. WDT error occurrence and revision of timer handler (as yet unproven*)
   c. PCI I/F hang-up and addition of retry function (as yet unproven*)

   Case 1

   * Measures were taken based on assumptions on the problems but their effectiveness has not been confirmed as the problems only occurred on site.

2. Addition of new functions to old kernel
   a. Addition of Precision Time Protocol (PTP) function
   b. Peripheral function update to implement whitelist function
   c. Addition of DMA function to improve UART performance

   Case 2

3. Others
   a. Application of security patches as necessary
   b. Addition of logging & dump to analyze less frequent problems

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Issues after Linux Application

Case 1

Oops & kernel panic with e1000 driver

What happened

- Sudden reboot with watch dog timer error

General description

- Kernel panic occurred during continuous energization on site.
- e1000 driver was identified from a back-trace.
- The incident occurred after 3 years of product shipment.

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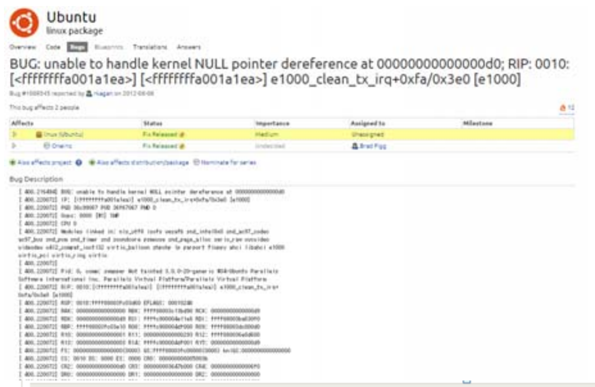
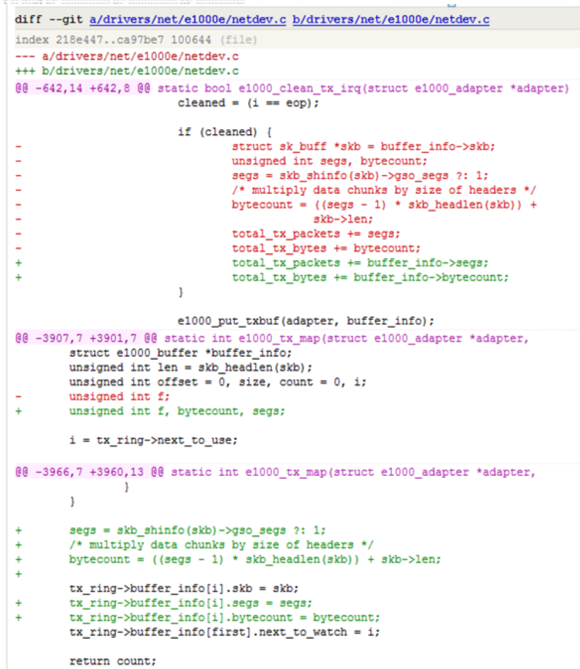
Issues after Linux Application

Source:
https://bugs.launchpad.net/ubuntu/+source/linux/+bug/1009545





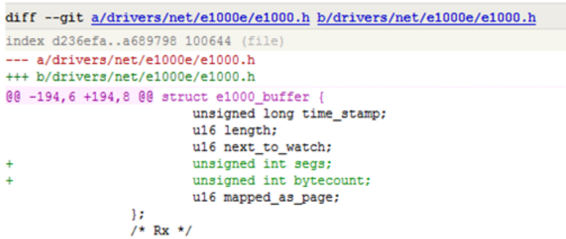
```
diff --git a/drivers/net/e1000e/netdev.c b/drivers/net/e1000e/netdev.c
index 218e447..ca97be7 100644 (file)
--- a/drivers/net/e1000e/netdev.c
+++ b/drivers/net/e1000e/netdev.c
@@ -642,14 +642,8 @@ static bool e1000_clean_tx_irq(struct e1000_adapter *adapter)
                        cleaned = (i == eop);

                        if (cleaned) {
-                               struct sk_buff *skb = buffer_info->skb;
-                               unsigned int segs, bytecount;
-                               segs = skb_shinfo(skb)->gso_segs ?: 1;
-                               /* multiply data chunks by size of headers */
-                               bytecount = ((segs - 1) * skb_headlen(skb)) +
-                                           skb->len;
-                               total_tx_packets += segs;
-                               total_tx_bytes += bytecount;
+                               total_tx_packets += buffer_info->segs;
+                               total_tx_bytes += buffer_info->bytecount;
                        }

                        e1000_put_txbuf(adapter, buffer_info);
@@ -3907,7 +3901,7 @@ static int e1000_tx_map(struct e1000_adapter *adapter,
        struct e1000_buffer *buffer_info;
        unsigned int len = skb_headlen(skb);
        unsigned int offset = 0, size, count = 0, i;
-       unsigned int f;
+       unsigned int f, bytecount, segs;

        i = tx_ring->next_to_use;

@@ -3966,7 +3960,13 @@ static int e1000_tx_map(struct e1000_adapter *adapter,
                }
        }

+       segs = skb_shinfo(skb)->gso_segs ?: 1;
+       /* multiply data chunks by size of headers */
+       bytecount = ((segs - 1) * skb_headlen(skb)) + skb->len;
+
        tx_ring->buffer_info[i].skb = skb;
+       tx_ring->buffer_info[i].segs = segs;
+       tx_ring->buffer_info[i].bytecount = bytecount;
        tx_ring->buffer_info[first].next_to_watch = i;

        return count;
```

Driver check

- Easily found a driver patch for the problem

Too much time elapsed after product shipment

- Is this patch simply applicable to the kernel being used for products without problem...?



```
diff --git a/drivers/net/e1000e/e1000.h b/drivers/net/e1000e/e1000.h
index d236efa..a689798 100644 (file)
--- a/drivers/net/e1000e/e1000.h
+++ b/drivers/net/e1000e/e1000.h
@@ -194,6 +194,8 @@ struct e1000_buffer {
                        unsigned long time_stamp;
                        u16 length;
                        u16 next_to_watch;
+                       unsigned int segs;
+                       unsigned int bytecount;
                        u16 mapped_as_page;
                };
                /* Rx */
```

Patch contents check

- The scale is smaller than expected and there is no problem!

This issue was fixed but what about other patches?

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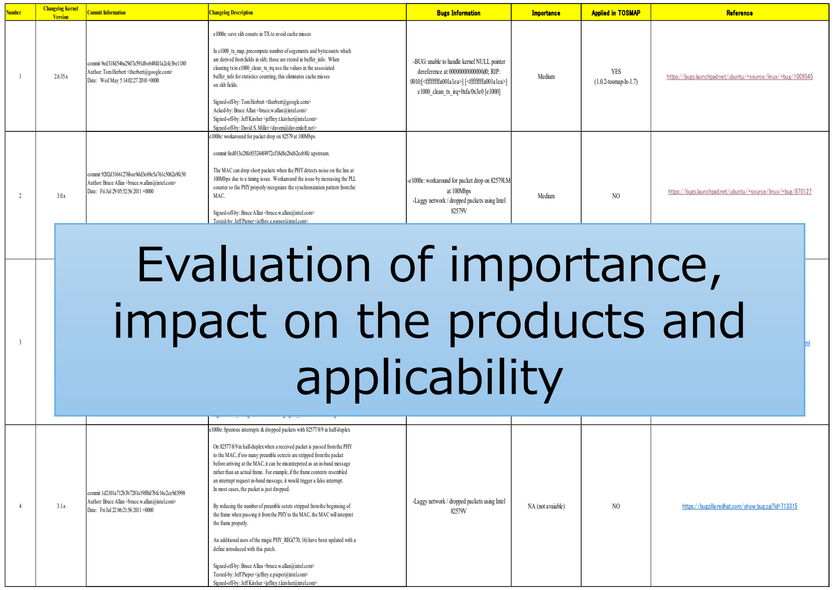
Issues after Linux Application

Checked the update history of hardware drivers being used

Target hardware

- LAN driver : Approx. 450
- Super I/O* : Approx. 70
- I2C : Approx. 50

* WDT, LED and UART



Check method

- Step 1: Get all the change log of kernel (upstream).
- Step 2: Get all commit log from changelog related to drivers.
- Step 3: Filter BUG FIX from list of commit logs.
- Evaluation with the help of internal kernel experts

Fortunately there happened to be no item that pose problems but the checking required great effort.

Issues after Linux Application

Case 2

Addition of new functions to existing products

What happened

- Development conducted to add the following functions
  - Precision Time Protocol (PTP) function
  - Whitelist function for security
  - DMA function to improve UART performance
- Hard to support these functions in our existing products

General description

- Backports were no more necessary because development of applying to CIP had just started.
- However this kind of additions might be happened in the future.
- On such an occasion, we are willing to utilize CIP and also contribute to CIP.

CIP will motivate us to perform backporting for useful functions to be added in the future.

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CIP Utilization and Contribution to CIP

CIP utilization

From Case 1

- Driver bug fix patch to be utilized
- Kernel processing patch to be utilized

From Case 2

- Motivation to backport new function leading to long-term maintenance
- Cooperation and consultation for backports of new functions possibly

Contribution to CIP

- Backport functions to be shared with CIP
- Information of requests and issues in using products to be shared with CIP
- Merging kernels and drivers that we have corrected into the mainline

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Summary

Today's presentation

- Embedded-Linux-applied our products
- Issues after Linux application that we experienced
- Utilization of and contribution to CIP

Hope CIP members be increased & long-term maintenance be shared by everyone in CIP

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Thank you

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