Devicetree BOF

ELCE 2018
Edinburgh, UK

Frank Rowand, Sony

October 24, 2018
181021_1535

My Goal

Do NOT show all of the slides

Agenda

- Collect questions, areas of interest
- Past events
- Future events
- New since elc 2017
- dtc compiler update
- Overlay update
- questions, comments, issues, concerns from the crowd

What do you want to talk about?

questions

comments

issues

concerns

Plumbers 2017 Summary

September 2017
Los Angeles

Was not scheduled
-- not enough interest / commitment

Devicetree Workshop Oct 2017

Prague, Czech Republic

after elce

Devicetree Workshop Oct 2017

Prague, Czech Republic

https://elinux.org/Device_tree_future
#Kernel_Summit_2017.2C_Devicetree_Workshop

- slides
- notes

Main topic areas:

=== Validation Tools & Schema

=== Runtime usage

=== DTS maintenance issues

=== More stuff

Devicetree Workshop 2017

```
 9:30 Welcome and Schedule bashing
 9:40 Encoding and Schema checking: Framing the problem
 9:45 DT YAML encoding overview
10:00 YAML encoding discussion
10:20 DT Schema format - option 1
10:35 DT Schema format - option 2
10:50 DT Schema discussion - what should go in the spec?
11:50 Code Generation from DT
12:10 Runtime memory consumption
14:30 Overlay maintenance plan
14:45 Avoiding duplicate descriptions
15:00 Criteria for accepting board files
15:15 Location for maintaining bindings - how to handle
         foreign bindings
15:30 Sharing Generic bindings
15:45 ABI Stability
16:00 [break and overflow discussion]
16:30 DT health check
16:50 devicetree.org update
17:05 EBBR Discussion
17:20 Closing and feedback
```

Plumbers 2018

November 13 - 15, 2018
Tuesday - Thursday
Vancouver, British Columbia, Canada

co-located with the Linux Kernel Summit

Plumbers session:
Wednesday 14 November, morning

Devicetree Specification

(old news…)

Devicetree Specification 0.1 supersedes ePAPR for the Linux kernel, continues to evolve

https://www.devicetree.org/specifications/

Mail list, Build Instructions, etc

https://www.devicetree.org/collaborate/

Repository

https://github.com/devicetree-org/devicetree-specification

dtc Compiler

dtc Compiler

commits from February 10, 2017 to date in dtc repo

- YAML encoded output format
    * for validation tools
- new library: pylibfdt
- ability to make nodes conditional on them being referenced
    * size reduction
- overlay syntactic sugar
    * eliminate hard coding overlay metadata
- fdtoverlay
    * standalone tool to apply overlay(s)

dtc - Devicetree Build Checks

Rob has been enhancing dtc error checks

Enabled for “W=1” builds

$ make V=0 W=1 qcom-apq8074-dragonboard.dtb

```
make[1]: Entering directory `/local/frowand_nobackup/src/git_linus/build/dragon_linus_4.10'
  DTC     arch/arm/boot/dts/qcom-apq8074-dragonboard.dtb
Warning (unit_address_vs_reg): Node /memory has a reg or ranges property, but no unit name
Warning (unit_address_vs_reg): Node /soc/spmi@fc4cf000/pm8941@0/vadc@3100/die_temp
Warning (unit_address_vs_reg): Node /soc/spmi@fc4cf000/pm8941@0/vadc@3100/ref_625m
Warning (unit_address_vs_reg): Node /soc/spmi@fc4cf000/pm8941@0/vadc@3100/ref_1250
Warning (unit_address_vs_reg): Node /soc/spmi@fc4cf000/pm8941@0/vadc@3100/ref_gnd h
Warning (unit_address_vs_reg): Node /soc/spmi@fc4cf000/pm8941@0/vadc@3100/ref_vdd h
make[1]: Leaving directory `/local/frowand_nobackup/src/git_linus/build/dragon_linus_4.10'
```

dtc - Devicetree Build Checks

commits from February 10, 2017 to date in dtc repo

add SPI bus checks
add I2C bus checks
drop warning for missing PCI bridge bus-range
add graph binding checks
add a check for duplicate unit-addresses of child nodes
add chosen node checks
add aliases node checks
check for #{size,address}-cells without child nodes
add string list check for *-names properties
add string list check
add a string check for 'label' property
add interrupts property check
add gpio binding properties check
add phandle with arg property checks
Warn on node name unit-addresses with '0x' or leading 0s
Add bus checks for simple-bus buses
Add bus checks for PCI buses
Add Warning for stricter node name character checking
Add Warning for stricter property name character checking

Overlay

Overlay

- U-Boot overlay support
  - enhancements have been added

Alternative to Linux kernel overlay loader
for some use cases

overlay validation - Linux kernel

Patches under review on mail list, not yet accepted to main line - may change

[PATCH v4 00/18] of: overlay: validation checks, subsequent fixes
Mon, 15 Oct 2018 19:37:20 -0700

https://lore.kernel.org/lkml/
1539657458-24401-1-git-send-email-frowand.list@gmail.com/T/#u

Overlay loader remains out of tree, so validation will only be visible for unittest, FPGAs, or if you use the out of tree overlay loader

Exposed errors in core devicetree code
Fixes are in the patch series

validation - ERROR, WARNING

WARNING: memory leak will occur if overlay removed, property: <prop_path>

cause: property add or modify in node not created by an overlay

ERROR: memory leak before free overlay changeset, <node_path>

cause: too many of_node_put()

ERROR: memory leak, expected refcount 1 instead of <refcount>, of_node_get()/of_node_put() unbalanced - destroy cset entry: attach overlay node <node_path>

cause: too many of_node_get() or not enough of_node_put()

validation - ERROR

Malformed FDT will not cleanly apply

ERROR: changing value of #address-cells is not allowed in <node_path>

ERROR: changing value of #size-cells is not allowed in <node_path>

ERROR: multiple fragments add and/or delete node <node_path>

ERROR: multiple fragments add, update, and/or delete property <prop_path>

ERROR: multiple fragments add and/or delete node <node_path>

```
# drivers/of/unittest-data/overlay_bad_add_dup_node.dts:

// SPDX-License-Identifier: GPL-2.0
/dts-v1/;
/plugin/;

/*
 * &electric_1/motor-1 and &spin_ctrl_1 are the same node:
 *   /testcase-data-2/substation@100/motor-1
 *
 * Thus the new node "controller" in each fragment will
 * result in an attempt to add the same node twice.
 * This will result in an error and the overlay apply
 * will fail.
 */

&electric_1 {

        motor-1 {
                controller {
                        power_bus = < 0x1 0x2 >;
                };
        };
};

&spin_ctrl_1 {
                controller {
                        power_bus_emergency = < 0x101 0x102 >;
                };
};
```

ERROR: multiple fragments add, update, and/or delete property <prop_path>

```
# drivers/of/unittest-data/overlay_bad_add_dup_prop.dts:

// SPDX-License-Identifier: GPL-2.0
/dts-v1/;
/plugin/;

/*
 * &electric_1/motor-1 and &spin_ctrl_1 are the same node:
 *   /testcase-data-2/substation@100/motor-1
 *
 * Thus the property "rpm_avail" in each fragment will
 * result in an attempt to update the same property twice.
 * This will result in an error and the overlay apply
 * will fail.
 */

&electric_1 {

        motor-1 {
                rpm_avail = < 100 >;
        };
};

&spin_ctrl_1 {
                rpm_avail = < 100 200 >;
};
```

Linux Internal ERROR

ERROR: of_node_release(), unexpected properties in <node_path>

Metadata

How should the metadata required by overlays be encoded in the FDT?

Discussion was in progress on devicetree-compiler list

> Subject: [RFC] devicetree: new FDT format version
> Message-ID: <b96829f9-2e8b-fdc5-5090-58591e2260cf@gmail.com>
> Date: Mon, 22 Jan 2018 00:09:18 -0800

side-effect: update of FDT format required

Metadata

Motivation:

- size reduction of FDT and kernel data
- remove metadata from tree name space

side-effects:

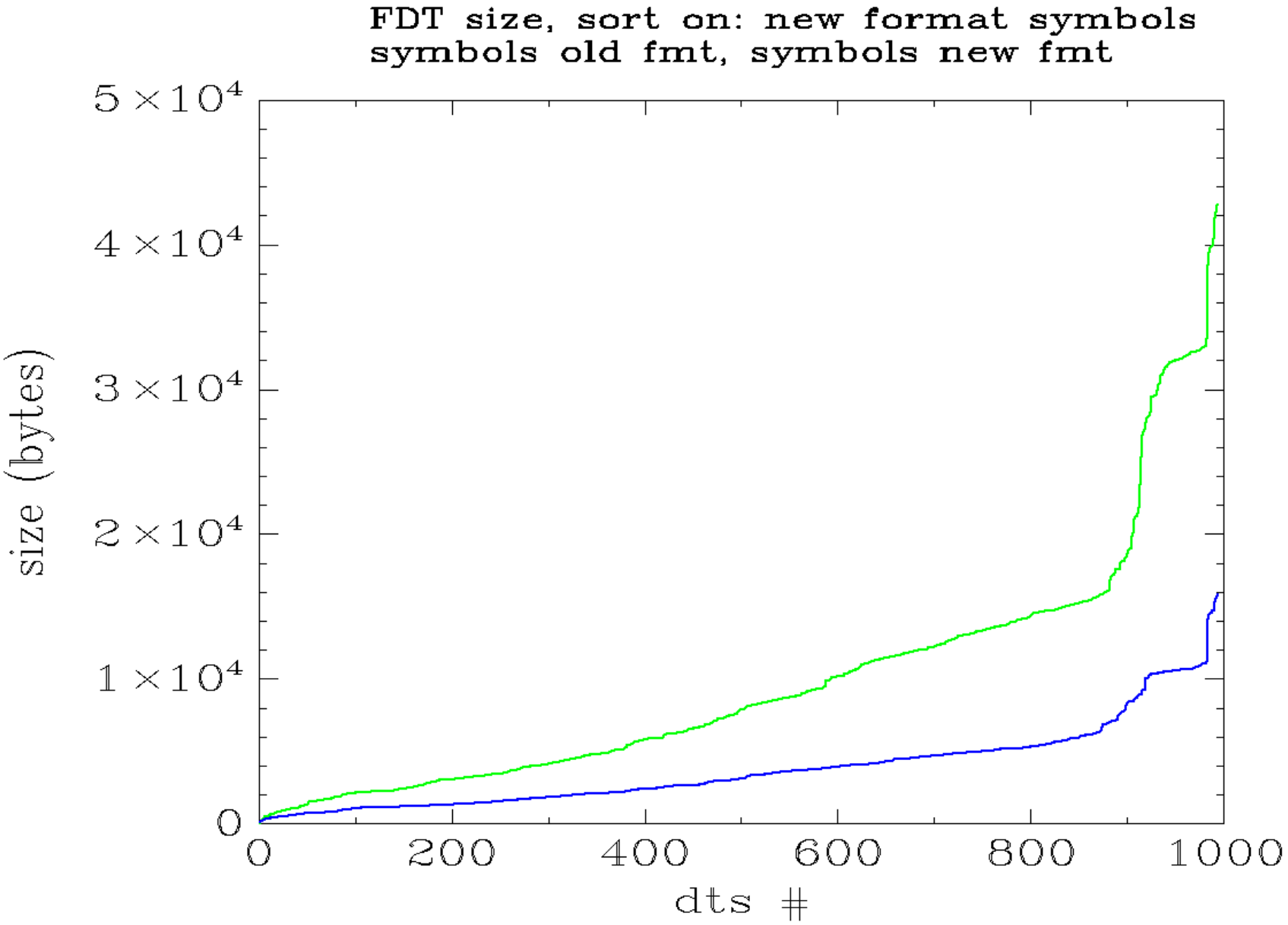
- update of FDT format required
- additional features possible, eg
  * phandle as property value decompile
  * validation features

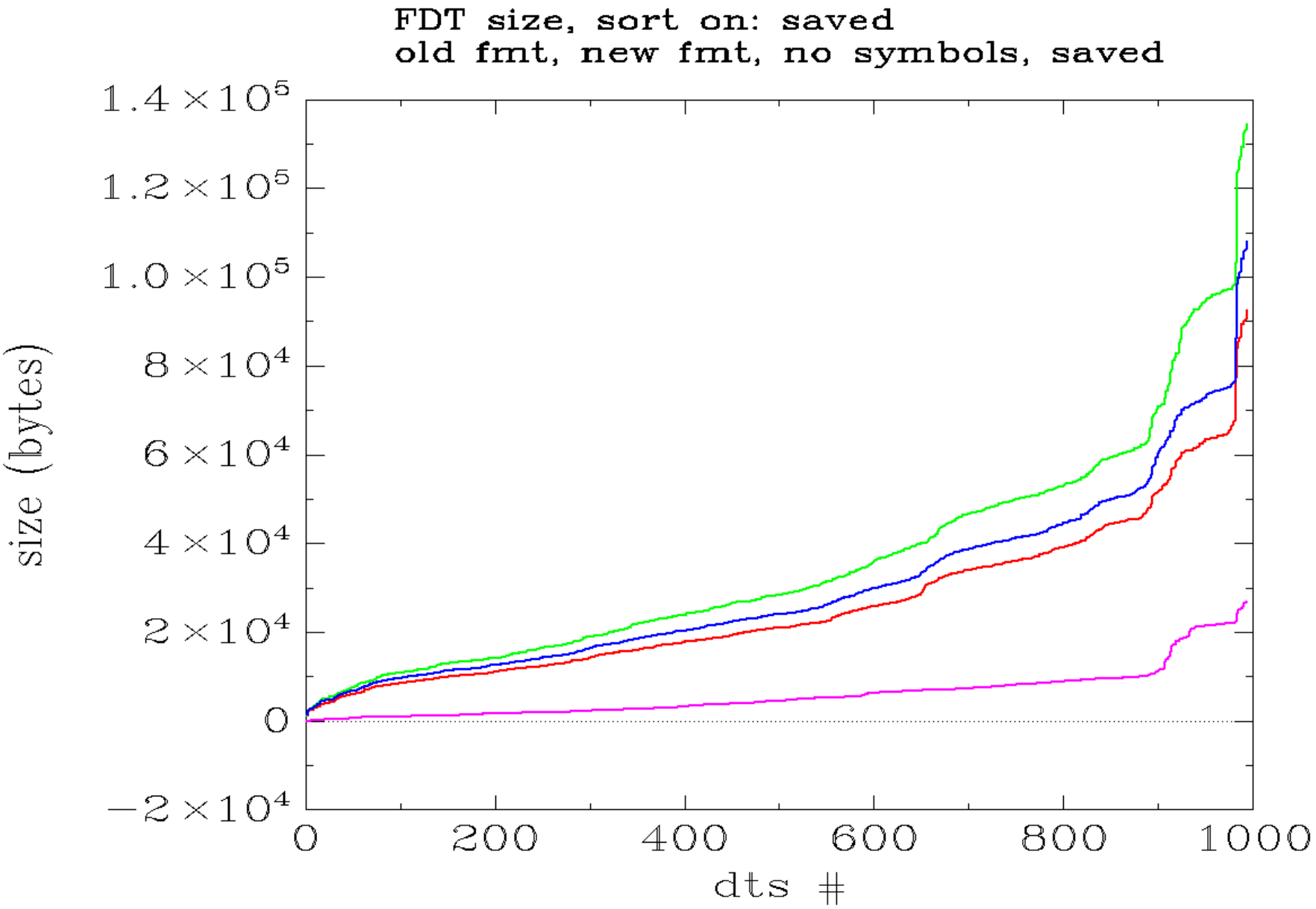
Metadata - base FDT overhead

Metadata overhead measured for arch/arm/boot/dts/*

“**symbols old fmt**” is added size from '**dtc -@**'
for the current FDT format

“**symbols new fmt**” is added size from '**dtc -@**'
for first proposed format in the email thread


FDT size, sort on: new format symbols
symbols old fmt, symbols new fmt
size (bytes)
5 ×10⁴
4 ×10⁴
3 ×10⁴
2 ×10⁴
1 ×10⁴
0
0
200
400
600
800
1000
dts #


FDT size, sort on: saved
old fmt, new fmt, no symbols, saved
size (bytes)
1.4×10^5
1.2×10^5
1.0×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
−2×10^4
0
200
400
600
800
1000
dts #

Metadata - base FDT overhead

Metadata overhead measured for arch/arm/boot/dts/*

row	dtb no symbols	delta symbols	delta new fmt	bytes saved
99%	90531	42721	15766	26955
83%	44302	14582	5163	9419
66%	26277	11662	4628	7034
49%	21047	7328	2754	4574
33%	12864	4305	1705	2600
16%	12009	2929	1520	1409
0%	1220	68	149	-81

- “**delta symbols**” is added size from '**dtc -@**'
- “**new fmt**” is added size from '**dtc -@**' **for first proposed in the email thread**

dtc - overlays - Linux v4.15

dtc creates the .dtb **OVERLAY INTERNAL DATA ("metadata")**

Do not hand code overlay internal data nodes in DTS source:

fragment@
__overlay__
__fixup__
__local_fixup__
__symbols__

dtc - overlays - example - old.dts

```
/dts-v1/;
/plugin/;

/ {
        fragment@0 {
                target-path = "/soc/base_fpga_region";
                #address-cells = <1>;
                #size-cells = <1>;

                __overlay__ {
                        ranges = <0x00000000 0x00000000 0xc0000000 0x00040000>,
                                 <0x00000001 0x00000000 0xff200000 0x00001000>;

                        external-fpga-config;

                        #address-cells = <2>;
                        #size-cells = <1>;

                        fpga_pr_region0 {
                                compatible = "fpga-region";
                                fpga-bridges = <&freeze_controller_0>;
                                ranges;
                        };

                        freeze_controller_0: freeze_controller@100000450 {
                                compatible = "altr,freeze-bridge-controller";
                                reg = <0x00000001 0x00000450 0x00000010>;
                                interrupt-parent = <&intc>;
                                interrupts = <0 21 4>;
                        };
                };
        };
};
```

dtc - overlays - example - new.dts

```
/dts-v1/;
/plugin/;

&fpga_region {
        ranges = <0x00000000 0x00000000 0xc0000000 0x00040000>,
                 <0x00000001 0x00000000 0xff200000 0x00001000>;

        external-fpga-config;

        #address-cells = <2>;
        #size-cells = <1>;

        fpga_pr_region0 {
                compatible = "fpga-region";
                fpga-bridges = <&freeze_controller_0>;
                ranges;
        };

        freeze_controller_0: freeze_controller@100000450 {
                compatible = "altr,freeze-bridge-controller";
                reg = <0x00000001 0x00000450 0x00000010>;
                interrupt-parent = <&intc>;
                interrupts = <0 21 4>;
        };
};
```

dtc - overlays - example

```
$ diff -b -u old.dts new.dts
--- old.dts
+++ new.dts
@@ -1,13 +1,7 @@
 /dts-v1/;
 /plugin/;

-/ {
-        fragment@0 {
-                target-path = "/soc/base_fpga_region";
-                #address-cells = <1>;
-                #size-cells = <1>;
-
-                __overlay__ {
+&fpga_region {
                         ranges = <0x00000000 0x00000000 0xc0000000 0x00040000>,
                                  <0x00000001 0x00000000 0xff200000 0x00001000>;

@@ -28,6 +22,4 @@
                                 interrupt-parent = <&intc>;
                                 interrupts = <0 21 4>;
                         };
-                };
-        };
 };
```

dtc - overlays - new.dts - no label?

```
/dts-v1/;
/plugin/;

&fpga_region {
        ........
};
```

What if there is no label for the overlay target in the base devicetree?

What if the overlay target is the root node (dtc does not allow a label on the root node)?

dtc - overlays - example - new.dts

```
/dts-v1/;
/plugin/;

&{/soc/base_fpga_region} {
        ranges = <0x00000000 0x00000000 0xc0000000 0x00040000>,
                 <0x00000001 0x00000000 0xff200000 0x00001000>;

        external-fpga-config;

        #address-cells = <2>;
        #size-cells = <1>;

        fpga_pr_region0 {
                compatible = "fpga-region";
                fpga-bridges = <&freeze_controller_0>;
                ranges;
        };

        freeze_controller_0: freeze_controller@100000450 {
                compatible = "altr,freeze-bridge-controller";
                reg = <0x00000001 0x00000450 0x00000010>;
                interrupt-parent = <&intc>;
                interrupts = <0 21 4>;
        };
};
```

next expected format change

Explicit connector node

.dtsi source vs overlay .dtsi

(More slides available after the 'END' slide)

Overlays

https://elinux.org/Frank%27s_Evolving_Overlay_Thoughts

What do you want to talk about?

questions

comments

issues

concerns

How to get a copy of the slides

1) frank.rowand@sony.com

2) http://elinux.org/Device_Tree

3) http://events.linuxfoundation.org

THE END

Thank you for your participation...

.dtsi source vs overlay .dtsi

With the new dtc --

Overlay .dts file contains directives:

```
/dts-v1/;
/plugin/;
```

.dtsi include file does not

Use include as .dtsi or overlay

With sugar syntax, the syntax used by an overlay is now compatible with the syntax used by an include file, if the include file uses labels as paths instead of using explicit paths.

- This may be convenient for development workflows

- Do not become dependent on this for overlays that will be long lived -- current thinking is that we want many / most overlays to use the connector model

Use include as .dtsi or overlay

---------- base tree ----------

```
$ expand fpga_tree.dts
/dts-v1/;

/* labels used by overlay are in the base tree */

/ {
        soc {
                intc: interrupt_ctrl {
                };
                fpga_region: base_fpga_region {
                };
        };
};

/include/ "fpga_plugin_or_dtsi.dts"
```

---------- overlay ----------

```
$ expand fpga_overlay.dts
/dts-v1/;
/plugin/;

/include/ "fpga_plugin_or_dtsi.dts"
```

The .dtsi

```
$ expand fpga_plugin_or_dtsi.dts
&fpga_region {
        ranges = <0x00000000 0x00000000 0xc0000000 0x00040000>,
                 <0x00000001 0x00000000 0xff200000 0x00001000>;

        external-fpga-config;

        #address-cells = <2>;
        #size-cells = <1>;

        fpga_pr_region0 {
                compatible = "fpga-region";
                fpga-bridges = <&freeze_controller_0>;
                ranges;
        };

        freeze_controller_0: freeze_controller@100000450 {
                compatible = "altr,freeze-bridge-controller";
                reg = <0x00000001 0x00000450 0x00000010>;
                interrupt-parent = <&intc>;
                interrupts = <0 21 4>;
        };
};
```

Tools

Kernel Configuration Info -- OLD

In tree

```
scripts/dtc/dt_to_config                                    \
    arch/arm/boot/dts/qcom-apq8074-dragonboard.dts          \
    --short-name                                            \
    --config ${KBUILD_OUTPUT}/.config                       \
    --config-format                                         \
    > dragon_config_info
```

```
$ grep -i coincell dragon_config_info
```

```
# -d-c-----n--F : coincell@2800 : qcom,pm8941-coincell : drivers/misc/qcom-coincell.c : CONFIG_QCOM_COINCELL : n
# CONFIG_QCOM_COINCELL is not set
# CONFIG_QCOM_COINCELL=y
```


-d-c-----n--F : coincell@2800 : qcom,pm8941-coincell : .....
CONFIG_QCOM_COINCELL is not set
CONFIG_QCOM_COINCELL=y

Debug Tools - OLD - update

dtc: dts source location annotation

- Provide source locations from .dts & .dtsi
- Several proof of concept versions on devicetree-compiler list, up to October 2015
- ~~Stalled, awaiting some of Frank's bandwidth~~

Project picked up by Julia Lawall

```
To:     devicetree-compiler@vger.kernel.org
Subject: [PATCH 1/3 v4] annotations: check for NULL position
Date:   Fri,  2 Feb 2018 21:41:48 +0100
```

source location annotation (old)

```
----- short format  -----

sdhci@f9824900 { /* qcom-apq8074-dragonboard.dts:14 */
      compatible = "qcom,sdhci-msm-v4"; /* qcom-msm8974.dtsi:240 */
      reg = <0xf9824900 0x11c 0xf9824000 0x800>; /* qcom-msm8974.dtsi:241 */
      reg-names = "hc_mem", "core_mem"; /* qcom-msm8974.dtsi:242 */
      interrupts = <0x0 0x7b 0x0 0x0 0x8a 0x0>; /* qcom-msm8974.dtsi:243 */
      interrupt-names = "hc_irq", "pwr_irq"; /* qcom-msm8974.dtsi:244 */
      clocks = <0xd 0xd8 0xd 0xd7>; /* qcom-msm8974.dtsi:245 */
      clock-names = "core", "iface"; /* qcom-msm8974.dtsi:246 */
      status = "ok"; /* qcom-apq8074-dragonboard.dts:17 */
      bus-width = <0x8>; /* qcom-apq8074-dragonboard.dts:15 */
      non-removable; /* qcom-apq8074-dragonboard.dts:16 */
}; /* qcom-apq8074-dragonboard.dts:18 */
```

Debug Tools -- semi-OLD

scripts/dtc/dt_prop

- Compare properties accessed on target system vs a device tree (dtX)
- available on elinux.org
- ~~Plan to submit to mail list “any day now”~~
  ==> Stalled, awaiting some of Frank's bandwidth

dt_prop example snippets

```
$ dt_prop --td dmesg_4.5-rc5_160307_2100 qcom-apq8074-dragonboard.dts

# --- dmesg_4.5-rc5_160307_2100
# +++ qcom-apq8074-dragonboard.dts
 /dts-v1/;


                // *****   i2c@f9964000 disabled  *****
                i2c@f9964000 {
+                       #address-cells;
+                       #size-cells;
+                       clock-names;
+                       clocks;
                        compatible;
+                       interrupts;
+                       reg;
                        status;
                };
```

Debug Tools - OLD

dt_node_info, dt_stat

- Aids boot (or module load) debugging
- Status of device creation, devicetree nodes, driver discovery, driver binding
- proof of concept on elinux.org
- Stalled, awaiting some of Frank's bandwidth

dt_node_info example 1

```
$ dt_node_info coincell
===== devices

===== nodes
/soc/spmi@fc4cf000/pm8941@0/qcom,coincell@2800 qcom,

===== nodes bound to a driver

===== nodes with a device

===== nodes not bound to a driver
/soc/spmi@fc4cf000/pm8941@0/qcom,coincell@2800 qcom,

===== nodes without a device
/soc/spmi@fc4cf000/pm8941@0/qcom,coincell@2800 qcom,
```

dt_node_info example 2

```
$ dt_node_info coincell
===== devices
/sys/devices/platform/soc/fc4cf000.spmi/spmi-0/0-00/

===== nodes
/soc/spmi@fc4cf000/pm8941@0/qcom,coincell@2800 qcom,

===== nodes bound to a driver

===== nodes with a device
/soc/spmi@fc4cf000/pm8941@0/qcom,coincell@2800 qcom,

===== nodes not bound to a driver
/soc/spmi@fc4cf000/pm8941@0/qcom,coincell@2800 qcom,

===== nodes without a device
```

Overlays -- more stuff...

Overlays - some use cases

- Expansion slots / external connectors
  - beaglebone
  - raspberry pi
  - minnowboard
  - C.H.I.P.
  - Arduino
  - seeedstudios Grove 4 pin connectors
  - others?
- FPGA

Overlays - some use cases

- Combinatorial explosion of .dts / .dtb files

  example:

  Devicetree Hardware Autoconfiguration
  Hans de Goede
  ELC Europe 2016

Overlays, one of the gating factors

```
On 10/18/17 14:46, Frank Rowand wrote:

> On Wed, 2017-10-18 at 10:44 -0500, Rob Herring wrote:

>> The issue remains that the kernel is not really setup to deal with any
>> random property or node to be changed at any point in run-time. I
>> think there needs to be some restrictions around what the overlays can
>> touch. We can't have it be wide open and then lock things down later
>> and break users.

> That paragraph is key to any discussion of accepting code to apply overlays.
> Solving that issue has been stated to be a gating factor for such code from
> the beginning of overlay development.
```

(Not the only remaining issue.)

Overlays, Linux kernel progress

(Not a complete list)

- overlay.c refactored
- resolver.c refactored
- hand coded overlays in devicetree source files
  - resolved by sugar syntax if base tree has required labels
  - continued dtc enhancements underway
- papered over issue: free FDT or expanded devicetree while pointers into them still exist
- unable to free overlay FDT and overlay expanded device tree after overlay removal (memory leak)
- FDT format update up in the air
- of locking architecturally broken
- pre-removal checks needs to ensure relevent driver(s) unbind
- connectors architecture up in the air
- overlay semantics not fully specified
- overlay manager (do not accept until gating requirements are resolved)

Devicetree Development History

Some random statistics

v4.2.. arch/*/boot/dts/ commits

```
   550  arc
 54641  arm
 13170  arm64
     4  c6x
    44  cris
    93  h8300
    33  metag
     2  microblaze
  1054  mips
    31  nios2
     7  openrisc
   797  powerpc
    25  sh
   115  xtensa
```

arch/*/boot/dts/ commits

v4.2	638	
v4.3	592	
v4.4	666	
v4.5	725	
v4.6	682	
v4.7	722	
v4.8	674	
v4.9	719	2017 02 19
v4.10	768	2017 04 30
v4.11	632	
v4.12	658	
v4.13	687	
v4.14	725	
v4.15	762	

arch/*/boot/dts/ commits

	arm	arm64	
v4.2	568	36	
v4.3	535	46	
v4.4	553	67	
v4.5	571	137	
v4.6	511	149	
v4.7	559	117	
v4.8	498	156	
v4.9	489	195	
v4.10	519	235	2017 02 19
v4.11	456	151	2017 04 30
v4.12	434	217	
v4.13	381	283	
v4.14	401	294	
v4.15	503	219	

.../bindings/ commits

v4.2	488	
v4.3	411	
v4.4	418	
v4.5	467	
v4.6	428	
v4.7	445	
v4.8	418	
v4.9	453	
v4.10	491	2017 02 19
v4.11	421	2017 04 30
v4.12	468	
v4.13	460	
v4.14	494	
v4.15	438	

scripts/dtc/ commits

```
v4.2        2
v4.3        0
v4.4        0
v4.5        0
v4.6        3
v4.7        1
v4.8        1
v4.9        0
v4.10       0       2017 02 19
v4.11       1       2017 04 30
v4.12       6
v4.13       6
v4.14       2
v4.15       4
```

drivers/of/ commits

v4.2	29	
v4.3	16	
v4.4	38	
v4.5	22	
v4.6	29	
v4.7	40	
v4.8	30	
v4.9	24	
v4.10	28	2017 02 19
v4.11	19	2017 04 30
v4.12	32	
v4.13	36	
v4.14	38	
v4.15	52	

v4.10.. top drivers/of/ commits

(February 19, 2017 ..)

What have patch topics been?

Very imprecise topic count (do not take the list too seriously...)

Based mostly on leading fields of patch subject

v4.10.. top drivers/of/ commits

(loosely based by patch comment tag)

```
23 overlay
10 device property
12 test
 7 of_mdio
 7 irq
 6 fdt
 6 of_graph
 6 device
 5 pci
 4 platform
 3 base
```

Resources

http://elinux.org/Device_Tree_presentations_papers_articles
http://elinux.org/Device_Tree_presentations_papers_articles#debug

http://elinux.org/Device_Tree_Reference

Resources

Devicetree Documentation

elinux.org/Device_Tree_Reference

- becoming more complete
- contributions and comments welcome

Resources

dtx_diff
dtc --annotate
dt_node_info

Solving Device Tree Issues:
Frank Rowand, elce 2015
http://elinux.org/images/0/04/Dt_debugging_elce_2015_151006_0421.pdf
(In this presentation, dtx_diff was named dtdiff.)

Supporting material for: Solving Device Tree Issues:
http://elinux.org/Device_Tree_frowand
section: Embedded Linux Conference Europe (ELCE) - October 6, 2015

dt_to_config

Solving Device Tree Issues - Part 2:
Frank Rowand, LinuxCon Japan 2016
http://elinux.org/images/5/50/Dt_debugging_part_2.pdf

Resources

dt_prop

Solving Device Tree Issues - Part 3:
Frank Rowand, elce 2016
http://elinux.org/images/e/e5/Dt_debugging_part_3.pdf

Supporting material for: Solving Device Tree Issues - Part 3:

kernel patches
scripts/dtc/dts_diff
scripts/dtc/dt_prop
http://elinux.org/Device_Tree_frowand
section: Resources for "Solving Device Tree Issues - Part 3" talk