

# How to get your Devicetree schema bindings accepted in less than 10 iterations

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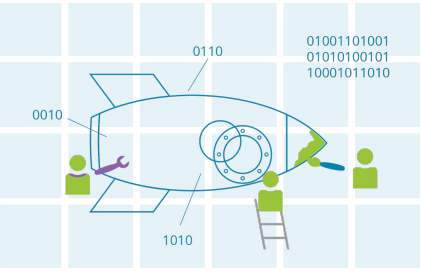
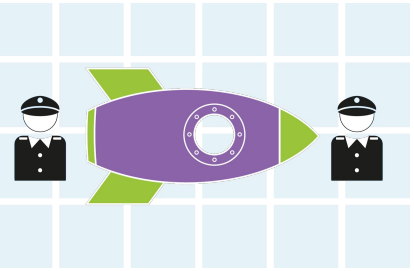
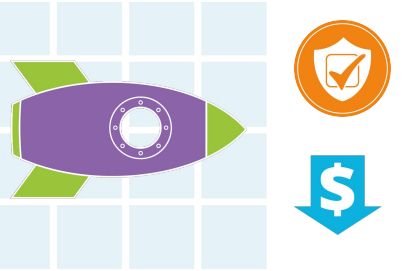

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# Introduction

- Krzysztof Kozlowski
- I work for Linaro in Qualcomm Landing Team / Linaro Developer Services
- I am the co-maintainer (with Rob and Conor) of Devicetree bindings in Linux kernel
- I also maintain other Linux kernel pieces
  - Memory controller drivers
  - NFC, 1-Wire subsystem
  - Samsung Exynos SoC ARM/ARM64 architecture

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# Agenda

1. Introduction
2. Generic rules for bindings
3. DT schema - usage
4. Dos and Don'ts
5. Reusable patterns (reference)
6. References
7. Q&A



# Disclaimer

- Devicetree and its bindings are not necessarily tied to specific system, however the talk focuses on Linux kernel Devicetree bindings and its DT schema format
- The guidelines here are based on my experience - received and given reviews
- Due to time constraints material presented here is simplified, thus when it contradicts Linux kernel documentation or DT bindings maintainer decision, the latter takes precedence

# Bindings and Devicetree schema

- While Devicetree sources (DTS) describe the hardware, the bindings describe the rules how DTS should be constructed
- Therefore the bindings also reference the hardware, not the chosen software implementation
  - Not describing Linux drivers
  - Documenting the interface for different implementations
- Previously, bindings in Linux kernel were written in text, without any specific format
- Devicetree schema (DT schema) is the new format which allows:
  - Validation of the bindings itself against meta-schema
  - Validation of the DTS against bindings
- All new bindings must come in DT schema
- Changes to existing TXT bindings:
  - Adding compatibles allowed
  - Adding properties not allowed, please convert the bindings to DT schema first

# Example DTS and DT schema

```
spi {  
    #address-cells = <1>;  
    #size-cells = <0>;  
  
    adc@0 {  
        compatible = "adi,ad7291";  
        reg = <0>;  
        vref-supply = <&adc_vref>;  
    };  
};
```

```
(...)  
title: AD7291 8-Channel, I2C, 12-Bit SAR ADC with Temperature Sensor  
description: |  
    Analog Devices AD7291 8-Channel I2C 12-Bit SAR ADC with Temperature  
    Sensor  
  
properties:  
    compatible:  
        const: adi,ad7291  
  
    reg:  
        maxItems: 1  
  
    vref-supply:  
        description: The regulator supply for ADC reference voltage.  
  
required:  
    - compatible  
    - reg  
additionalProperties: false
```



# Generic rules for bindings

- Most of the rules are already covered by <https://www.kernel.org/doc/html/latest/devicetree/bindings/writing-bindings.html>
- Just like DTS, the Devicetree bindings describe the hardware, not the software implementation (e.g. Linux kernel drivers)
  - Bindings are independent of implementation
  - Might be used in several other projects
  - Avoid using Linuxisms (Linux-specific subsystem naming)
  - Do not describe software policies, e.g. what OS should do
- Devicetree and bindings are for non-discoverable hardware
  - No need to create properties if they can be discovered by the drivers





# Generic rules for bindings - patches

- Dual license (GPL-2.0-only OR BSD-2-Clause)
- Bindings filename based on the compatible
  - vendor,device.yaml
  - vendor,soc-ip.yaml
- Bindings headers are also part of the bindings
  - Dual license
  - vendor,device.h
- Bindings changes should not be mixed with a driver code in one patch
  - Sent bindings as separate patches, first in the patchset

# Generic rules for bindings - compatibles

- Compatible
  - Should be specific, so matching exact hardware
    - No wildcards
    - Avoid device-family names like SoC-family, but use specific device as fallback
      - "qcom,sm8550-gpi-dma", "qcom,sm6350-gpi-dma";
  - Generic SoC IP block compatibles make sense sometimes, if all devices are truly compatible and driver uses it for matching
    - Prepend with specific compatible
      - "qcom,sm8550-dsi-ctrl", "qcom,mdss-dsi-ctrl";
  - For devices on the the bus (e.g. I2C, SPI) - no bus suffixes
    - Bad: vendor,foo-spi
    - Good: vendor,foo

# Generic rules for bindings - syscon and simple-mfd

- **syscon and simple-mfd require device-specific compatible as first one**
  - `"qcom,sc7280-tcsr", "syscon";`
  - `"qcom,qcs404-imem", "syscon", "simple-mfd";`
- **simple-mfd**
  - “simple-mfd” means “there's nothing in this node that any of the child nodes depend on”
  - Usually means that device is simple, e.g. does not have any properties except children
    - No resources like clocks, resets or power-domains
    - Nothing else except the children
  - Do not overuse it just to avoid creating a driver for your device
- **syscon**
  - Register region containing a set of miscellaneous registers, not representing a specific device
  - Not a work-around for laziness, e.g. avoiding proper phy or reset driver

# Generic rules for bindings - properties

- Focus on hardware characteristics and features, instead of specific device programming model
  - Good:
    - regulator-min-microvolt  
(which uses uV as units)
  - Bad:
    - Using device register values to encode logical unit:

```
regulator-min-voltage:
  $ref: /schemas/types.yaml#/definitions/uint32
  enum:
    - 1      # 0.2 V
    - 2      # 0.3 V
    - 3      # 0.4 V
    - 4      # 0.5 V
```



A close-up, slightly blurred photograph of a person's hands working on a green printed circuit board (PCB). The PCB is populated with numerous electronic components, including integrated circuits, capacitors, and connectors. The person is wearing a checkered shirt. The background is dark and out of focus.

# Devicetree Schema

# DT schema - usage

- There is a guide with an example:
  - <https://www.kernel.org/doc/html/latest/devicetree/bindings/writing-schema.html>
- DT schema is written in YAML (using json-schema vocabulary)
- Typical installation and usage:

```
pip3 install dtschema yamllint

# test the bindings:
make dt_binding_check DT_SCHEMA_FILES=trivial-devices.yaml
make dt_binding_check DT_SCHEMA_FILES=qcom
make dt_binding_check DT_SCHEMA_FILES=/gpio/
```



# DT schema - testing DTS

- Validating DTS against bindings

```
export ARCH=arm64 ... # cross compile for your arch

# Check all the DTSES against all bindings (very long):
make dtbs_check

# Check all the DTSES against given bindings (still might be long):
make dtbs_check DT_SCHEMA_FILES=trivial-devices.yaml

# Check one DTS against all bindings - provide a Makefile target:
make CHECK_DTBS=y qcom/sm8450-hdk.dtb

# Check one DTS against given bindings:
make CHECK_DTBS=y DT_SCHEMA_FILES=trivial-devices.yaml qcom/sm8450-hdk.dtb
```





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# Dos and Don'ts





# Dos and Don'ts - properties

- If there is standard property - use it
  - Look for existing ones in:
    - <https://github.com/devicetree-org/dt-schema/tree/main/dtschema/schemas>
    - Documentation/devicetree/bindings/gpio/gpio-consumer-common.yaml
    - Other bindings, especially common parts
- Custom properties require:
  - Vendor prefix (foo,property-name)
  - Type (\$ref), unless standard unit (see later)
  - Description - describe the feature or hardware, not the Linux driver behavior

```
qcom,avg-samples:  
  $ref: /schemas/types.yaml#/definitions/uint32  
  description:  
    Number of samples to be used for measurement.
```



# Dos and Don'ts - no need for types

- No need for type (\$ref) for properties:
  - With standard unit suffixes do not need a type (\$ref)  
[dtschema.com/schemas/property-units.yaml](https://dtschema.com/schemas/property-units.yaml)
  - Described by core schema

```
entry-latency-us:  
  description:  
    Worst case latency in microseconds required to enter  
    the idle state.
```

```
a2vdd-supply:  
  description: A 1.8V supply that powers up the A2VDD pin.
```

```
interrupts:  
  maxItems: 1
```



# Dos and Don'ts - arrays

- Items of reg, clocks, dmas, interrupts, resets and others are always strictly ordered
  - The xxx-names (e.g. clock-names) are only helpers
  - Don't use clk/irq suffix in names: "tx" instead of "txirq"
  - Both of these properties (xxx and xxx-names) must have strict constraints on size and order of items
- Declare the items via a list with descriptions

```
clocks:
  items:
    - description: 24 MHz reference
    - description: bus clock
clock-names:
  items:
    - const: ref
    - const: bus
```



# Dos and Don'ts - arrays continued

- If minItems==maxItems, only maxItems is enough (although not necessarily in allOf:if:then block)

```
resets:  
  maxItems: 2  
  description: phandles to the reset lines for both SATA bridges  
reset-names:  
  items:  
    - const: sata0  
    - const: sata1
```

- Use maxItems:X for obvious cases (or if xxx-names describes the items)

```
reg:  
  maxItems: 1
```



# Dos and Don'ts - syscon phandles

- Phandle to syscon device requires a vendor, descriptive name and a description

- Bad:

```
syscon:  
  $ref: /schemas/types.yaml#/definitions/phandle
```

- Good:

```
samsung,sysreg:  
  $ref: /schemas/types.yaml#/definitions/phandle  
  description: Phandle to System Register syscon
```



# Dos and Don'ts - syscon phandles continued

- When phandle comes with arguments:

```
samsung,sysreg:
  $ref: /schemas/types.yaml#/definitions/phandle-array
  items:
    - items:
      - description: phandle to System Register syscon node
      - description: offset of SW_CONF register for this controller
  description:
    The phandle to System Register syscon node for the same
    domain where this USI controller resides
```



# Dos and Don'ts - additional/unevaluated

- `additionalProperties` and `unevaluatedProperties` control how other properties are treated (the ones not mentioned in the current schema)
- Most cases: choose either `additionalProperties` or `unevaluatedProperties` and set it to *false*
- If schema does not reference any other schema (no top-level `$ref`):

```
properties:  
  ...  
  
required:  
  ...  
  
additionalProperties: false
```



# Dos and Don'ts - additional/unevaluated

- If schema references other schema (\$ref), you can list applicable properties from other schema and do not allow anything else:

```
allOf:
  - $ref: panel-common.yaml#

properties:
  backlight: true          # coming from panel-common.yaml
  reset-gpios: true        # coming from panel-common.yaml
  ...

required:
  ...

additionalProperties: false
```





# Dos and Don'ts - additional/unevaluated

- Allow all fields from the other schema
  - This is preferred if the referenced schema is in general valid for your device and any of its properties can be applicable, e.g. regulator.yaml

```
patternProperties:
  "^LDO[1-3]$":
    type: object
    $ref: regulator.yaml#
    unevaluatedProperties: false
```

```
allOf:
  - $ref: panel-common.yaml#
properties:
  ...
  unevaluatedProperties: false
```



# Dos and Don'ts - examples

- Example is used to validate the DT schema
- Include useful DTS example(s)
  - ...but not 10 examples with difference in compatibles only
- Use 2- or 4-space indentation for DTS example
  - 4-space is preferred, nicely aligns with the opening -|

```
examples:
- |
    adc@0 {
        compatible = "adi,ad7190";
        reg = <0>;
    };
```



# Dos and Don'ts - examples continued

- No “status=okay/disabled” in the examples
- No unnecessary consumer examples inside provider bindings (e.g. clock controllers)
  - In that context, the usage of consumer is obvious
  - Not related to particular provider
- Device node names should be generic (“adc”, not “ad7190”)
  - [Devicetree spec: 2.2.2. Generic Names Recommendation](#)

# Reusable patterns (reference)



# Reusable patterns (reference)

## Excluding properties or depending on property presence:

```
allOf:  
  # If qcom,gsi-loader is present, modem-init must not be present  
  - if:  
    required:  
      - qcom,gsi-loader  
  then:  
    properties:  
      modem-init: false
```



# Reusable patterns (reference)

## Property required and present only in one variant:

```
allOf:  
  - if:  
    properties:  
      compatible:  
        contains:  
          const: vendor,soc2-ip  
  then:  
    required:  
      - foo-supply  
  else:      # Otherwise the property is not allowed:  
    properties:  
      foo-supply: false
```



# Reusable patterns (reference)

## Excluding properties, but one is required:

oneOf:

- required:
  - reg
- required:
  - size



# Reusable patterns (reference)

## Excluding properties and none is required:

```
allOf:
```

```
- not:
```

```
  required:
```

- i2c-gpio,scl-has-no-pullup
- i2c-gpio,scl-open-drain





# Reusable patterns (reference)

## Array of integers with some constraints (e.g. min/max values):

properties:

vendor,int-array-variable-length-and-constrained-values:

description: Array might define what type of elements might be used

\$ref: /schemas/types.yaml#/definitions/uint32-array

minItems: 2

maxItems: 3

items:

minimum: 0

maximum: 8



# Reusable patterns (reference)

## Variable length arrays (per variant):

```
properties:
  clocks:
    minItems: 2
    maxItems: 4
  clock-names:
    minItems: 2
    maxItems: 4
...
```

```
...
allOf:
  - if:
      properties:
        compatible:
          contains:
            const: foo,bar
    then:
      properties:
        clocks:
          minItems: 4
        clock-names:
          items:
            - description: ...
```



# Reusable patterns (reference)

- [Dependency between properties](#)
- [Restricting property based on other one](#)
- [Variable length of array - last interrupt optional](#)
- [Phandle to syscon with offset](#)
- [uint32 matrix, variable length of two-items tuples](#)
- [\\$ref depending on compatible](#)
- [Device on either I2C or SPI bus](#) (same compatible)

# References

- Writing bindings:  
<https://www.kernel.org/doc/html/latest/devicetree/bindings/writing-bindings.html>
- Writing DT schema:  
<https://www.kernel.org/doc/html/latest/devicetree/bindings/writing-schema.html>
- Example schema:  
<https://www.kernel.org/doc/html/latest/devicetree/bindings/writing-schema.html#example-schema>
- Standard property types/suffixes:  
<https://github.com/devicetree-org/dt-schema/blob/main/dtschema/schemas/property-units.yaml>
- dt-schema core schemas:  
<https://github.com/devicetree-org/dt-schema/tree/main/dtschema/schemas>

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# Linaro membership collaboration





# Thank you

Questions?



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