PA-APIs: Looking beyond power intent specification formats

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Abstract
Power Management affects design functionality, hence both tools and users need to be aware of this information. The traditional approaches to query information don’t work for power aware designs as information is captured in different formats, e.g., UPF, HDL and Liberty. The paper provides details of an abstract data model for Power Aware design and the interface to query the information. This can be used to provide standard access to power management information.

Access to Power Aware Information
Access to power aware information is not just significant for tool developers but also to design and verification engineers. Some typical requirements are:
- Develop utilities for design intent exploration
- Generate a customized report of power intent specification formats
- Understand the power management of an IP and then accordingly create the power intent of the SOC depending upon characteristics of the IP.
- Develop custom checking utilities that can be incorporated into a quality checking flow.
- Check that an isolation clamp value matches the reset value.
- Create an environment to automatically generate coverage monitors and assertions for power management.

Obstacles to accessing PA Information
There are various challenges to accessing information related to power management.
- Power management information is specified separately from HDL in UPF and Liberty files.
- UPF relies more on tool automation to simplify specification and hence its difficult to inspect UPF files for extracting information.
- UPF provides some Tcl Query commands which are incomplete and inconsistent to be used for accessing information.

Modeling the Power Aware Information
A model that captures the information related to power management for a given design and provides simplified interface to access the information.

PA Information Model

| Primary holders of information | PA Attribute
|-------------------------------|-------------------------------
| PA Handle                     | PA Attribute
| UPF Objects                   | CP Attribute
| HDL Objects                   | PA Handle
| Relationship Objects          | PA Handle

PA Handle: A reference to an object in PA Information Model

UPF Objects
- Represents objects created by UPF
  - e.g., Power Domains, Supply Sets, Power States, etc.
- Captures information after application of power intent
- Can represent objects from different UPF versions and other power formats

HDL Objects
- Represents objects from HDL design hierarchy
- Object contains abstracted HDL information common across all HDL languages
  - e.g., hierarchical structure, name of ports/lines
- Only subset of HDL information is captured
  - necessary to represent power management architecture
  - e.g., control signals, creation scopes, -instance, etc.
- Additional HDL information can be accessed by getting full-hierarchical path of HDL object from PA Handle and then querying from other respective HDL Information Models.

Relationship Objects
- Represent some relationships between other objects
- Captures meta information which is not present in user design
  - e.g., Expressions, extents, cell information, etc.

Power Aware Application Programmable Interface (PA-API)
PA-API is the interface to access information from PA-Information Model. It can be implemented in different languages depending upon requirements.
- C Interface
  - Can be used to construct more sophisticated applications
- Tcl Interface
  - Allow querying power management information
- HDL Interface
  - Allow construction of high level testbenches

The PA-API is mainly designed to provide read only access to PA Information. However, there is some requirement to provide API to modify dynamic attributes during simulation in order to construct sophisticated testbenches at higher level of abstraction. This feature is currently under exploration.

UML Object Diagram of Information Model

Example Design

Conclusion
The PA-IM along with PA-APIs provides a well-defined structure and simplified access to power management information. This can be used across tools and design flows. It catches the result of the application of power intent and stores the abstract representation of HDL. Hence, it can represent the PA information at different levels of design abstraction – RTL or Gate Level and also from different sources (UPF, HDL, Liberty). The following work has been donated to IEEE P1801 UPF WG and the work is on to include this in UPF Standard.