Mobile 1394
Power Distribution Proposal

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Background

The IEEE 1394 high-speed serial bus provides capability for a device to either source power to 1394 cable attached devices bus or sink power from the cable (depending upon the capability of the device being attached).

The Physical Layer (PHY) of a node attached to the 1394 cable is required to remain powered to enable the ability of the PHY to relay transaction packets addressed to other nodes on the bus.

When one examines the power model of a mobile computing device (Personal Computer (PC) Notebook), it is apparent that a typical PC notebook is not capable of providing power levels which may be requested if it were to be a 1394 cable power provider. Battery life, AC power adapter capability, and thermal issues contribute to the inability of the PC notebook from providing more than a modest amount of power. The amount of power the PC notebook has the capability to deliver must, ultimately, be decided upon by the OEM developer. Typically, the maximum amount of power the PC notebook may be required to deliver would be to one or two notebook peripheral devices (e.g. external hard drive, floppy drive, CD-ROM, or camera).

Current PHY implementations and proposed implementations require a level of power consumption which exceeds the typical architectural power bounds of a PC notebook. An “always-on” PHY is not compatible with PC notebook power management architecture nor is it friendly toward the preservation of system battery life.

When multiple devices are attached to the 1394 cable, it is architecturally unfeasible for the PC notebook to continue to supply cable power. When a 1394 cable power provider is connected, the PC notebook can reduce the power drain on its own internal source by no longer providing a source of power to the PC notebook PHY or to the 1394 cable.

This proposal provides a preferred mechanism which can be used to automatically switch PHY power from a PC notebook provided source to a 1394 cable attached source. However, this proposal does enable the PC notebook to source a modest amount of power to a cable attached 1394 device when the PC notebook PHY is powered from the PC notebook source (AC adapter or battery).

Definitions

- **ACPI:** *Advanced Configuration and Power Interface;*- the method for describing hardware interfaces in terms abstract enough to allow flexible and innovative hardware implementations and concrete enough to allow shrink-wrap OS code to use such hardware interfaces.
- **ACPI Hardware;** *Computer hardware;* provides the features required to support Operating System Directed Power Management and containing the interfaces to those features using Description Tables as specified by the ACPI 1.0 specification.

- **S1:** *ACPI S1 Sleeping State;* S1 sleeping state is a low wake-up latency sleeping state. In this state, no system context is lost (CPU or chip set) and hardware maintains all system context.
- **S2:** *ACPI S2 Sleeping State;* S2 sleeping state is a low wake-up latency sleeping state. This state is similar to the S1 sleeping state except the CPU and system cache context is lost (the OS is responsible for maintaining the caches and CPU context). Control starts from the processor's reset vector after the wake-up event.
- **S3:** *ACPI S3 Sleeping State*; S3 sleeping state is a low wake-up latency sleeping state where all system context is lost except system memory. CPU, cache, and chip set context are lost in this state. Hardware maintains memory context and restores some CPU and L2 configuration context. Control starts from the processor's reset vector after the wake-up event.
- **S4:** *ACPI S4 Sleeping State*; S4 sleeping state is the lowest power, longest wake-up latency sleeping state supported by ACPI. In order to reduce power to a minimum, it is assumed that the hardware platform has powered off all devices. Platform context is maintained.
- **S5:** *ACPI S5 Sleeping State*; S5 state is similar to the S4 state except the OS does not save any context nor enable any devices to wake the system. The system is in the "soft" off state and requires a complete boot when awakened. Software uses a different state value to distinguish between the S5 state and the S4 state to allow for initial boot operations within the BIOS to distinguish whether or not the boot is going to wake from a saved memory image.
- **PC:** *Personal Computer*
- **OEM:** *Original Equipment Manufacturer*
- **PHY:** *Physical Layer*
- **Notebook Power:** *AC Brick or Main Battery*. Note: From the P3S point of view, it cannot tell the difference since the "raw" energy being delivered to it is not distinguishable whether it is being provided by the AC battery charger or the PC notebook main battery. The energy source input to the P3S is connected to the unregulated power rail of the PC notebook.
- **P3S:** *Power Source/Sink Switch* - Circuitry associated with a mechanism enabling automatic switching of the PHY power from the PC notebook source to the 1394 cable source when a 1394 power provider device is attached. When the 1394 power provider is removed from the cable connection, the PC notebook PHY power provider will revert back to the internal PC notebook source (providing there does not exist any other 1394 power provider attached to the cable connection). In addition, the P3S provides the ability for the PC notebook to provide minimal, unregulated, power to a 1394 cable attached device.
- **P2S:** *Port Signal Switch* - Circuitry associated with a mechanism enabling automatic "*pass-through*" switching for 1394 transaction signal pairs (transmit and receive) when the PC notebook "*disconnects*" from the bus immediately prior to entering an S3 suspend state.

- **2PR:** *PHY Power Regulator* - Circuitry associated with regulation of power exiting the PS3 prior to being delivered to the PC notebook PHY.

Assumptions

There are, as part of this proposal, a specific set of assumptions which must be considered and understood to be required within the scope of this proposal. They are:

1. A PC notebook implementation consisting of a P3S and a P2S will "*detach*" itself from the 1394 cable when the PC notebook enters a system S3 suspend state. Prior to entering S3, the PC notebook will notify 1394 devices attached to the cable of its intent to detach. If, during the notification process, the PC notebook discovers an attached 1394 device intolerant of the PC notebook detachment, the S3 operation will abort until the intolerant 1394 device is removed from the cable, disabled or becomes tolerant of the PC notebook detach.
2. The PC notebook is not required to supply power to any device capable of supplying its own power.
3. The PC notebook will only supply a modest amount of unregulated power to the 1394 cable. The voltage level of unregulated power will vary between the voltage level of the PC notebook internal main battery and the voltage level of the PC notebook external AC adapter power source (typically between 12 and 21 Volts). Communication between the PC notebook and the device attached to the cable through the PC notebook external 1394 port will establish the amount of power the attached device will be allowed to draw from the PC notebook. If the device requires an amount of power the PC notebook is not capable of providing, the PC notebook will not enable the device.

    NOTE: When operating in a full working state, a PC notebook typically consumes between 17 and 23 watts. This proposal assumes (and recommends) maximum power delivery from the PC notebook to the 1394 cable to be 10% (or less) of the total PC notebook power budget. Specifically, the PC notebook will only provide the 1394 cable with a total power between 1.7 and 2.3 watts. The total current drawn from the PC notebook for cable attached 1394 devices would range between 80 and 200 milliamps (assuming an unregulated voltage between 12 and 21 volts). Peripheral devices targeted for use in mobile 1394 cable environments must be designed within these power consumption constraints.
4. A PC notebook implementing a P3S mechanism will always automatically switch the source of cable power between the PC notebook and a 1394 cable power provider when a power provider is attached or removed from the 1394 cable to which the PC notebook is attached. Communication between the PC notebook and the cable power provider will establish the amount of power the PC notebook PHY will consume from the cable power provider.
5. Power distribution and leakage control for internal 1394 port attachment to the PHY are not part of this proposal. Solutions for issues associated with internal

1394 port attachments with implementation of any portion of this proposal are left to the individual OEM.

Components

This proposal contains three components. They are:

1. A PC notebook which supports a single external 1394 cable attach point and uses a PHY which does **not** provide a mobile friendly power management feature set (i.e. PHY implementations available as of this writing),
2. A PC notebook which supports two external 1394 cable attach points and uses a PHY which does **not** provide a mobile friendly power management feature set, and
3. A PC notebook which supports two external 1394 cable attach points and uses a PHY which **does** provide a mobile friendly power management feature set.

A fourth component (a PC notebook which supports a single external 1394 cable attach point and uses a PHY which **does** provide a mobile friendly power management feature set) could be submitted, however, this fourth component could easily be derived from component number three and, therefore, has not been included in this proposal.

A functional description of each component is provided in this proposal.

Single Attach (PHY *lacks* mobile power management features)

Figure One (below) presents a graphical representation of the first proposal component.

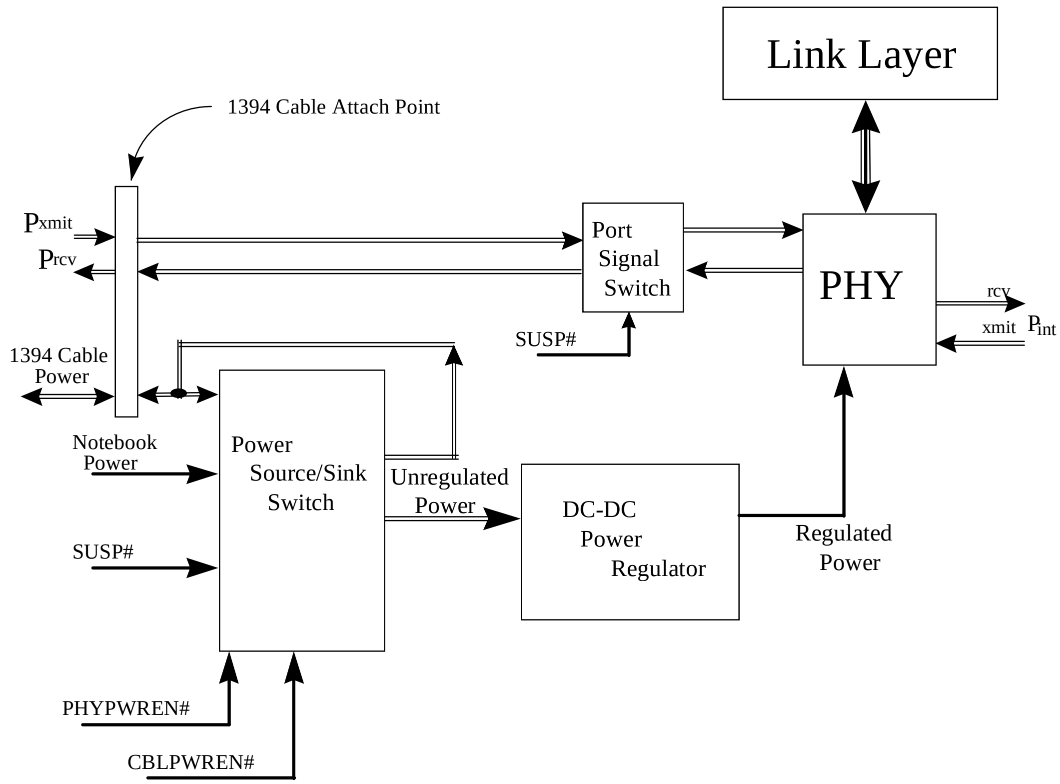

Figure One - Single External Cable Attach

In this instance, the PC notebook, when attached to the 1394 cable, is a leaf node device. The PC notebook responds to transaction packets addressed only to itself - it does not repeat transaction packets addressed to other nodes.

The PC notebook has the capability to communicate to other cable attached 1394 devices.

The PC notebook PHY may have one or more internal 1394 ports.

The Power Source/Sink Switch (P3S) detects 1394 cable provided power and will automatically connect the PC notebook PHY to the 1394 cable power - disconnecting the PC notebook PHY from the internal PC notebook power source.

If the P3S does not detect power on the 1394 cable, the PC notebook PHY will be automatically connected to the PC notebook internal power source.

When the PC notebook PHY power is connected to the PC notebook source, the unregulated power output of the P3S can be enabled to connect to the power rail of the 1394 cable via the **CBLPWREN#** signal. The PC notebook can also enable/disable power to the PC notebook PHY via the **PHYPWREN#** signal. Neither of these signals have any effect if the PC notebook PHY is powered from the 1394 cable.

When the PC notebook prepares to enter into an S3 suspend state, the PC notebook will communicate a disconnect intention to 1394 devices attached to the cable which may be dependent upon the PC notebook for service. Providing no cable attached 1394 device is dependent upon the PC notebook, the system will enter the S3 state and assert the PC notebook **SUSP#** signal. Assertion of **SUSP#** will remove unregulated power from the PC notebook PHY Power Regulator (2PR). Removal of unregulated power from 2PR does not remove any unregulated power delivered to the 1394 cable by the PC notebook. Unregulated power delivered to the 1394 cable by the PC notebook is only removed by assertion of the **CBLPWREN#** signal.

When the PC notebook PHY power is derived from the PC notebook source, assertion of **SUSP#** will remove the PC notebook PHY signal pairs (transmit and receive) from the 1394 cable connection via the Port Signal Switch (P2S). This prevents current leakage into the PC notebook PHY when it has been powered off. **SUSP#** does not affect the P2S if the PC notebook PHY is powered from the 1394 cable source.

Dual Attach (PHY *lacks* mobile power management features)

Figure Two (below) presents a graphical representation of the second proposal component.

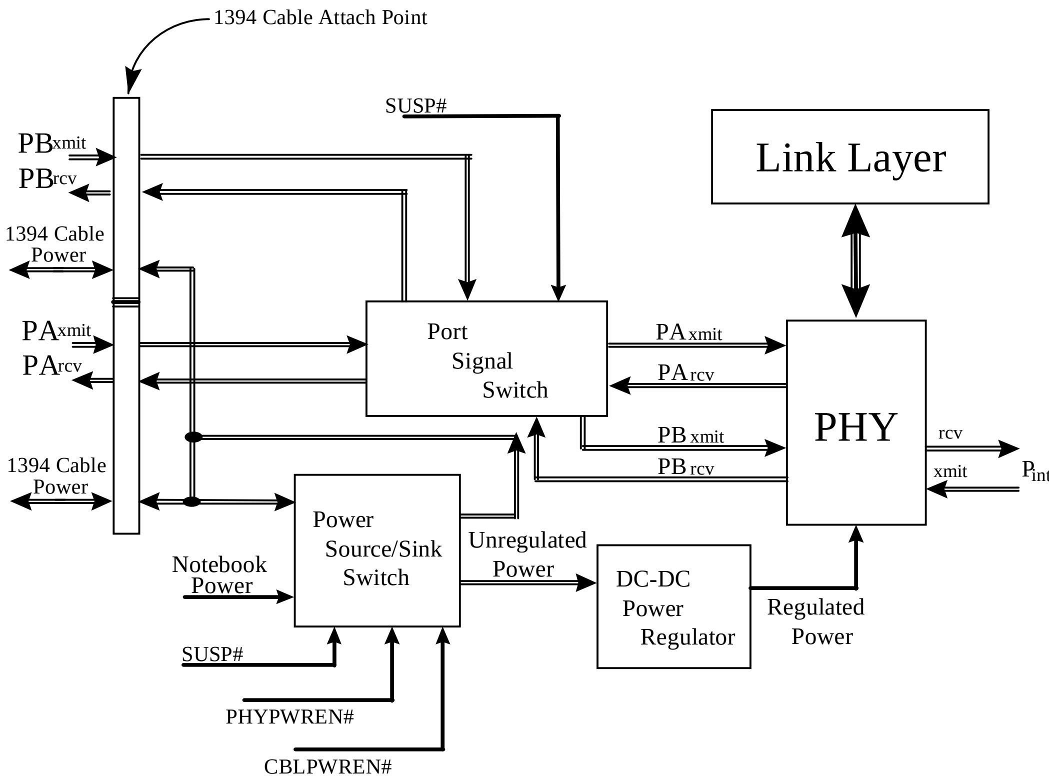

Figure Two - Dual Port External Cable Attach

In this instance, the PC notebook, when attached to the 1394 cable, responds to transaction packets addressed to itself and has the capability to repeat transaction packets addressed to other nodes.

The PC notebook has the capability to communicate to other cable attached 1394 devices.

The PC notebook PHY may have one or more internal 1394 ports.

The Power Source/Sink Switch (P3S) detects 1394 cable provided power and will automatically connect the PC notebook PHY to the 1394 cable power - disconnecting the PC notebook PHY from the internal PC notebook power source.

If the P3S does not detect power on the 1394 cable, the PC notebook PHY will be automatically connected to the PC notebook internal power source.

When the PC notebook PHY power is connected to the PC notebook source, the unregulated power output of the P3S can be enabled/disabled to connect to the power rail of the 1394 cable via the **CBLPWREN#** signal. The PC notebook can also enable/disable power to the

PC notebook PHY via the **PHYPWREN#** signal. Neither of these signals have any effect if the PC notebook PHY is powered from the 1394 cable.

When the PC notebook prepares to enter into an S3 suspend state, the PC notebook will communicate a disconnect intention to 1394 devices attached to the cable which may be dependent upon the PC notebook for service. Providing no cable attached 1394 device is dependent upon the PC notebook, the system will enter the S3 state and assert the PC notebook **SUSP#** signal. Assertion of **SUSP#** will remove unregulated power from the PC notebook PHY Power Regulator (2PR). Removal of unregulated power from 2PR does not remove any unregulated power delivered to the 1394 cable by the PC notebook. Unregulated power delivered to the 1394 cable by the PC notebook is only removed by assertion of the **CBLPWREN#** signal.

Assertion of the **SUSP#** signal will cause the Port Signal Switch (P2S) to configure the PC notebook PHY signal pairs (transmit and receive) for both 1394 cable connections to *"pass-through"* mode. *"Pass-through"* mode allows the 1394 transmit and receive signals for Port A to be physically connected to their counterparts on Port B (thus allowing packets to be relayed between ports). This will also prevents current leakage into the PC notebook PHY when the PC notebook PHY has been powered off.

<u>Dual Attach (PHY *provides* mobile power management features)</u>

Figure Three (below) presents a graphical representation of the third proposal component.

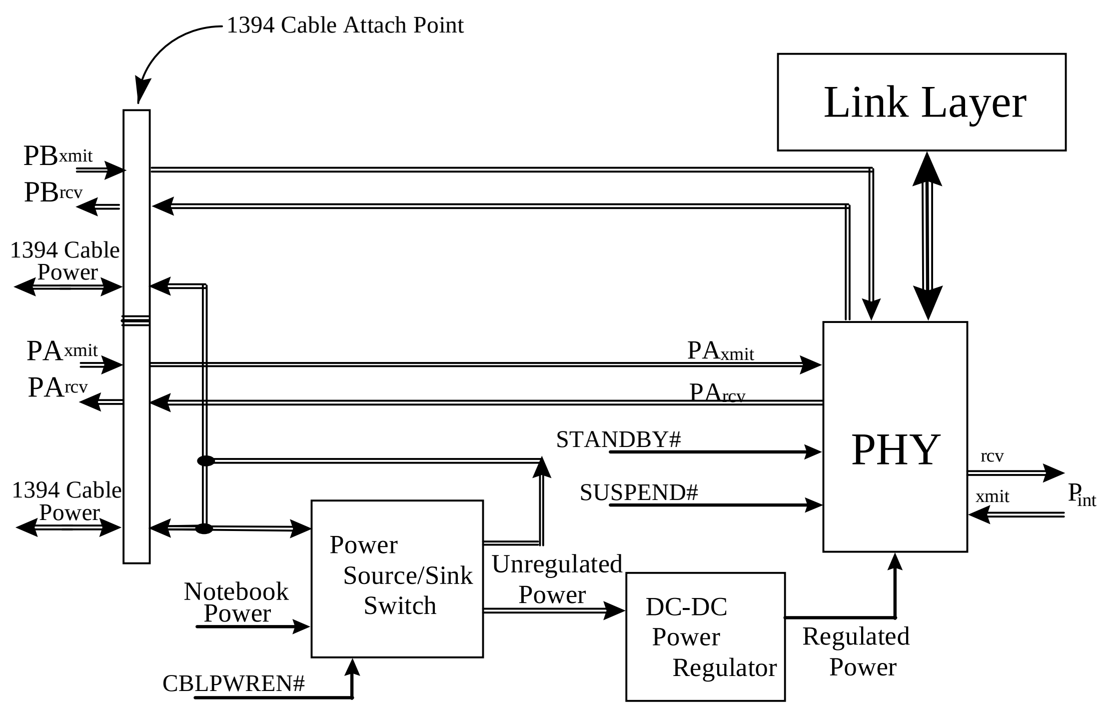

Figure Three - Dual Port External Cable Attach with mobile PHY

In this instance, the PC notebook, when attached to the 1394 cable, responds to transaction packets addressed to itself and has the capability to repeat transaction packets addressed to other nodes.

The PC notebook has the capability to communicate to other cable attached 1394 devices.

The PC notebook PHY may have one or more internal 1394 ports.

The Power Source/Sink Switch (P3S) detects 1394 cable provided power and will automatically connect the PC notebook PHY to the 1394 cable power - disconnecting the PC notebook PHY from the internal PC notebook power source.

If the P3S does not detect power on the 1394 cable, the PC notebook PHY will be automatically connected to the PC notebook internal power source.

When the PC notebook PHY power is connected to the PC notebook source, the unregulated power output of the P3S can be enabled/disabled to connect to the power rail of the 1394 cable via the **CBLPWREN#** signal. The **CBLPWREN#** signal has no effect when the PC notebook is powered from the 1394 cable source.

The protocol, process, and procedure to move the PC notebook PHY from a full S0 working state, through sleep state S1 and S2 into the S3 suspend is beyond the scope of this proposal and is presented in the "***Proposal for IEEE 1394 Suspend/Resume Capability***."

Practical Configurations

There are two configurations of sufficient interest to present within this proposal. They are:

1. PC Notebook with an external 1394 attached Device Bay
2. PC Notebook installed in a docking station via PC notebook 1394 external port cable interconnect.

Configuration One

A device bay which connects to the PC notebook via a 1394 cable attach point may or may not have its own source of power (e.g. some device bay configurations may include an AC "brick" as a means of providing self power).

If the device bay is not capable of providing its own source of power, the PC notebook will provide power within the constraints and guidelines provided within this proposal. If, however, the device bay is able to provide its own power, the PC notebook will not provide cable power. The PC notebook may (or may not) provide power to its own internal PHY depending upon the 1394 cable power capability of the device bay.

The self-powered device bay may have the ability to be a 1394 cable power provider. In this instance, the AC "brick" attaches to the device bay and the device bay attaches to the PC notebook via the 1394 external cable port. The PC notebook then becomes a power client - consuming power supplied from the device bay. The PC notebook may use power provided from the 1394 cable to charge its internal battery and power the PC notebook as well as the PC notebook PHY.

Interestingly, if the device bay is self powered via an internal device bay battery, the device bay may elect to still provide 1394 cable power. The PC notebook will not distinguish any difference between 1394 cable power provided via some battery source or from an AC "brick" source. The PC notebook will request a specific power budget - negotiation for delivery of the requested power budget occurs between the power provider and the power client.

Configuration Two

In this configuration, the PC notebook is attached to a docking station via an external 1394 cable interconnect port on the PC notebook. This configuration is identical to the self-powered device bay (supplying 1394 cable power) configuration described earlier. The docking station will always be powered from an AC source with the capability of providing full 1394 power source requirements (as specified in the 1394.a specification).

The PC notebook will derive its power (including charging currents) from the docking station through the 1394 cable interconnect. The PC notebook PHY will be powered from the cable source. All devices attached to the 1394 cable will receive their power from the cable source (docking station) - except self-powered devices.

If the PC notebook is undocked (removed from the 1394 interconnect cable) while still in the working state, the PC notebook will automatically switch to its internal main power source. If the internal power source of the PC notebook is incapable of maintaining the working state, the PC notebook may power-off or enter into a system sleep state (dependent upon the OEM system design).

The protocol encompassing the process of "*hot*" and "*warm*" docking and undocking differences between PCI (or ISA) docking and 1394 docking are beyond the scope of this proposal.

Implementation Caveats

There are two major areas which must be considered when implementing this proposal:

1. Cost,
2. Signal Switching dynamics.

The first (cost) is apparent and will not be discussed in detail within this proposal. Suffice it to be understood that signal switching and isolation practices within PC notebooks are fairly typical - they are not uncommonly used for resolving current leakage and signal routing issues.

The second (Signal Switching dynamics) may not be readily apparent and is brought forth here to encourage the designer be cautious in design implementation.

While not of major concern when implementing the P2S for systems with data rates in the megabit category, there are significant caveats when switching signals carrying transaction packets in the gigabit data rate range.

Care must be taken to pay particular attention to trasconductance and interconnect impedance matching. Issues to be resolved with the implementation are signal jitter, ringing, and reflection. These problems are injected into the design as a result of the impedance characteristics of the connectors and switching circuitry itself.

These issues are more prevalent with "*copper*" solutions as opposed to "*optical*" interconnect switching circuits. Optical interconnect switch circuits are, inheritantly, more costly than *field effect transistors* or *bi-polar microwave transistor logic.*

Call to Action

It is proposed, therefore, the mobile 1394 power distribution components contained within this document be presented (perhaps with normative circuit examples) to implementers of PC notebooks supporting 1394.a external cable devices as the preferred method of implementation.

Contact Information

The reader's input is welcome and formally solicited. Please submit all suggestions, concerns, enhancement ideas, etc. to:

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