CSE: How exactly does a DC power scheme work?

TSCHUDI: Power typically enters the data center at 480 volts AC. In the DC system, it's converted to 380 volts and then sent directly into the server. The server's first stage conversion is bypassed, allowing the DC to directly arrive at a point in the server that normally sees 380 volts DC. A flywheel UPS is connected to the 380-volt DC distribution to provide the capability to ride through disturbances or disruptions in the utility power.

LOVORN: There is a single conversation from the incoming power into the data center to DC, at either 12, 15, 24 or 48 volts. The DC voltage is then distributed directly to the server racks, and individual DC voltage converters change the distribution voltage to the many DC voltage levels utilized in a server. When AC power is used in the servers, there is a multi-tap transformer in the server power supply that transforms incoming power into fully rectified AC, which is filtered and converted into the various DC levels for the server.

SULLIVAN: AC-to-DC conversion is done in place of the present static UPS systems. The DC power is then distributed to computer equipment cabinets and subsequently to individual servers, which eliminates the AC-to-DC power supplies in the servers. At the same time, there is still DC-to-DC conversion within the servers to go from distribution DC voltages to operating DC voltages.

GODRICH: There are various configurations available for different environments and applications. For example, Google, several weeks ago, began urging manufacturers to go to 12-volt DC schemes at the server level. Some manufacturers are very comfortable with this approach, but the end-to-end concept remains for the consulting engineers.

The 48-volt DC approach is still one of the most popular, due to the fact that it is very safe and there is a vast amount of knowledge about these distributions from the telecom world.
including a wide spectrum of standards. Availability of these systems is a problem—most
were designed and operated for one failure in 20 years. The problem with this approach is the
size of the system, which is limited to, say, 500 kW in tele-data applications due to
distribution constraints. Even so, for small to medium data centers, this approach can be
applied successfully.

Implementation of a higher voltage distribution, say in the range of 550 volts DC, might solve
a lot of concerns. Using such concepts, and DC/DC converters at the row level, it is possible
to create 3- to 5-MW power blocks to supply data center modules in a reliable and safe way.

Another range that server manufacturers are very comfortable with is 340 to 380 volts DC.
Tests have been implemented successfully in the United States and Europe. ETSI even
implemented standards for 300-volt DC direct to the rack distribution several years ago,
although the solution didn't evolve successfully. We believe that such direct DC feed to
racks—not only to these servers, but spreading the range as much as possible under the
NEC voltage limitation to take advantage of distribution costs—is a viable solution for
relatively safe data center environments, but not for facilities with relatively high staff
dynamics.

For a financial data center environment with up to 15,000 changes per month, plant safety
concerns might be raised, but for a super-computer environment where once implemented it
becomes a 'machine-room' with minimum staff dynamics, this solution might be optimal.

CSE: What are the drawbacks of DC when compared with AC power?

GODRICH: DC cannot be implemented easily in existing AC data centers. The advantages
are mostly for new facilities. That said, small to medium applications have been
successfully implemented with proven economic advantages.

But due to the fact that the DC servers are not the most popular on the market, the price
of their power supply options is more expensive than anticipated.

In addition, not all manufacturers have a wide range of DC equipment. While the 48-volt to
250-volt DC range offers a lot of options, in the range of 250- to 1,000-volt DC, there are only
about four manufacturers in the market. There's also a lot left to do in the area of protection
relaying—to optimize the existing AC ranges to DC operation.

LOVORN: The primary drawback is the overwhelming cost of converting the existing
distribution system, where all of the equipment is designed and installed on a conventional
AC distribution system, as conversion to a DC system would require removing and replacing
nearly all of the AC distribution, UPS equipment, PDUs, panel boards, server power supplies
and everything else associated with power to the servers. Even in a new installation, the
relative installed costs may not justify the extra expense for small operational cost savings.

SULLIVAN: The biggest concern is the size of the conductors needed to distribute the DC
power. If standard DC voltages are utilized, bus bars, rather than wires in conduits, would be
required to handle the high currents.

CSE: Are there existing applications that can attest to the efficiency of DC power for data
centers?

SULLIVAN: A pilot demonstration project by Lawrence Berkeley National Labs (LBNL) this
year, found a 10% to 12% increase in efficiency. Although at least 20% efficiencies were
expected, they were not able to achieve that level with the equipment installed.

GODRICH: We actually designed, in the last year, the first multi-MW data center for high
density, 300 to 600 watts per sq. ft. Implementation of such an approach might improve the
end-to-end efficiency numbers to more than 25%.

Taking into account that a lot of elements are eliminated in the serial distribution, these
configurations have about a 17% lower probability of failure in a five-year span than
comparable AC configurations.

Companies like Rackable Systems, in Milpitas, Calif., have installed a number of
applications across the U.S. with great success. Tests performed by LBNL, EPRI and Sun
also look very promising. Most server manufacturers have equipment and are considering
expanding their DC equipment range.

TSCHUDI: There are numerous systems that operate on high voltage DC current. In fact, the
military uses DC in many applications and entire ships operate on DC. Also, transportation
systems operate on DC and elevators in New York use DC power. Adding to the list, the
telecommunications industry has a long history of operating on 48-volt DC in phone
switching centers—which has proven to be extremely reliable.

CSE: What will it take for DC power to become a more accepted and widespread choice for
data centers?

LOVORN: In my opinion, DC power distribution cannot overcome Ohm's law. Therefore, I do
not believe that it will ever be more widespread than some demonstration sites that show that
it is not economically viable.

GODRICH: There has to be a chain reaction with a positive techno-economical impact for the
client, with the first step being an understanding and requirement to design for higher
efficiency end-to-end. Server manufacturers generally will price their equipment based on the
military requirement such that the rack level will be more attractive. It will take time for DC-
power to approach the mainstream in data centers, but for some applications, it will get there
sooner than expected.

TSCHUDI: It's at the chicken-and-egg stage right now. At this time, pilot installations in
operating data centers are being planned to help spark demand and allow the server
manufacturers to start the certification process. Most likely a few early adopters will spark
the interest of many data center operators. The server manufacturers are ready and watching
the market, so it will be relatively simple for them to move if demand is present.
SULLIVAN: As mentioned, the first step will be getting a “critical mass” of computer equipment manufacturers to produce products that will function on DC power. Until then, a data center that converts would have to operate two power systems. Next, users must be educated about the benefits of installing equipment using DC power. Finally, engineers and service personnel will have to be educated and trained to design and service DC power systems and DC operated computer equipment.

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Tech Support for DC Power

How can an end user be assured of finding a DC power expert to assist with maintenance and repairs? “All the major equipment manufacturers have been supporting DC power systems for years,” says Kfir Godrich, director of technology development with EYP MCF, New York.

“In reality, there is little to differentiate AC and DC from an installation point of view,” suggests William Tschudi, principal investigator with Lawrence Berkeley National Labs. “For starters, all of the equipment for high-voltage DC is UL-rated, which means that it has undergone a rigorous safety evaluation.”

But Ken Lovorn, P.E., of Lovorn Engineering, Pittsburgh, cautions that finding maintenance and repair personnel familiar with DC distribution systems of this scale might prove difficult. “While some of these people from the early telephone central stations are still around and would have the expertise directly applicable to the DC data center systems, most of the newer technicians in the telephone industry are used to seeing servers that are similar to those in a data processing center and, thus, would be no better off than the technicians that are now servicing the data center power distribution systems,” he says.