Solution for communication with the transmission and distribution system substations :

DNP3, distributed network protocol, is used at layer 2 (data link layer), 4 (transportation layer) and 5 (application layer). This protocol provides multiplexing, data fragmentation, error detection and prioritation. It uses cyclic redundancy check codes to detect errors. Though DNP3 is more complex than the older protocol Modbus, we prefer to use DNP3 because t is more robust, efficient, and interoperable.

layer 4 : Transport :
The protocol used for transport layer is TCP or UDP. As we do not want to allow loss of paquets, we will use TCP.

Layer 3 : network
It consists in the routing of packets through routers. This layer is operated by the Internet protocol, the IP in TCP/IP. However, several other protocols are required at this layer :
ICMP, internet control message protocol, is used by routers to send error messages indicating, for instance, that a service is not available or that a router could not be reached.
ARP, address resolution protocol, is operated at the interface between layer 2 and 3. It enables to translate an IP address into a MAC address

IP header fields is composed of :
– Source and destination IP address
– Time-to-live, which is the number of routers the paquet can get through before being thrown
– Unique ID
– Checksum to detect corrupted data
– Options

IPv4 Header Format

| Offsets	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Version				IHL				DSCP						ECN		Total Length															
4	32	Identification																Flags			Fragment Offset												
8	64	Time To Live								Protocol								Header Checksum															
12	96	Source IP Address																															
16	128	Destination IP Address																															
20	160	Options (if IHL > 5)																															

Layer 2 : the datalink layer
It enables to transfer data between adjacent nodes on a link. The protocol used in this layer is the Ethernet protocol.
An ethernet frame header is composed of :
– Preamble
– Source and destination MAC address
– Acknowledgement number
– Payload size

– Cyclic redundancy check (CRC) to detect corrupted data

– 12-octet interframegap
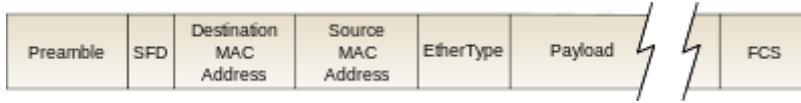
Layer 1 : The physical layer :

It enables the bit by bit delivery of the information. This layer uses Ethernet protocol like layer 2.

Communication requirements :

The following table presents the typical communication requirements from low to high.

Performance	Low	Medium	High
Speed/Data throughput	<10 kbps	>10 kbps < 1 Mbps	>1 Mbps
Response time	>1 s	<1 s >10 ms	< 0 ms
Time Synchronization	1 s	1 ms ± 0.1 ms	1 µs ± 0.5 µs
Avalanche Handling	No data through-put required during avalanche	Some data through-put required	All data through-put required
Data Integrity	Some errors allowed	Limited errors allowed	No errors allowed
Link Availability	All data can wait until link available	Some data can wait for a limited time	No data can wait
Data Priority	Can be sent after all other data	To be sent after high priority data; can wait for request	To be sent immediately; cannot wait for request

To meet the requirements on reliability and security, we need a protection scheme. Today, IEDs provide protection functions together with control functions, measurement, monitoring. We are dealing with a high level of communication from the protection AP to the SCADA. The requirements for a high level of communication is as follow :

Performance	level required	
Speed/Data throughput	low	< 10kbps
Response time	low	> 1s
Time synchronization	high	1 μs +/- 0,5 μs
Avalanche handling	low	no data throughput required during avalanche
Data integrity	high	No errors allowed
Link availibility	low	All data can wait until link available
Data priority	low	Can be sent after all other data

Regarding the choice of physical media, we will use fiber optics cable so as to meet the requirements. PowerCorp's power transmission and distribution grid is over a medium sized geographic area and contains two power plants and one larger factory. Thus, it is not a short transmission and distribution network and it would not be economically profitable to use coaxial cables or twisted-pair copper wires. Though fiber optics is expensive, it has low operation costs. Fiber optics also has a high capacity which would be useful for the 530000 household and 100 business customers of PowerCorp.

With fiber optics, the speed is 100 Gbps. ??? doesn't meet the requirements !