5 VAN Showcases

This chapter deals with the Industrial Experimental Setup (IES) of the VAN project, in other words, the project's prototypes. Two showcases were chosen to show VAN technologies and how they can be implemented within an industrial facility and interconnect several remote machines in order to validate the project's outputs. The chosen show cases were a Process Automation Industrial Experimental Setup (PA IES) and a Manufacturing Automation Industrial Experimental Setup (MA IES). These two scenarios represent different types of industrial facilities since their requirements regarding main VAN topics (wireless communication, real-time, safety and security) are quite different. For example, real time within the PA demonstrator require a more relaxed set of constraints than the MA demonstrator, since PA deals with processes which in general take long time to be finished and only need to be supervised, which can be done remotely. However, MA demonstrator deals with robots, conveyor belts and other types of machines that need to communicate faster and safer, since any kind of unexpected event or failure can end up in a facility or personal-in-charge damaged within instants of time. Also within a generic process plant (including power plants), human operators are kept apart behind their control panels to monitor and control the correct performance of the facility, therefore not needing such safety constraints as a manufacturing facility, where human operators can share the same space as machines, which if not operated safely, can hurt humans around them.

Regarding the PA demonstrator, it was decided to implement VAN solutions within Bio Power stations, which transform biological materials into fuels and energy. On the other hand, MA demonstrator is made of geographically distributed plants each one implementing different components of a manufacturing facility, such as a robot, conveyor belt and a machining line. The following paragraphs describe these prototypes and show results for VAN technologies applied to their showcases.

5.1 Process Automation Industrial Experimental Setup

5.1.1 Short description of technological plant to be controlled and necessity of using VAN solutions

The Bio Power stations are geographical distributed centres that produce bio-energy and Bio fuels

(Ethanol), based on selected biogenic waste materials and raw materials containing sugar and starch (see Fig 5-1). Components of Bio Power stations are:

- Production of bio-ethanol
- Fermentation of methane
- Production of organic NPP-fertilizers
- Hot cooled technology of block thermal power stations to deliver surplus of energy (electric and heat power)

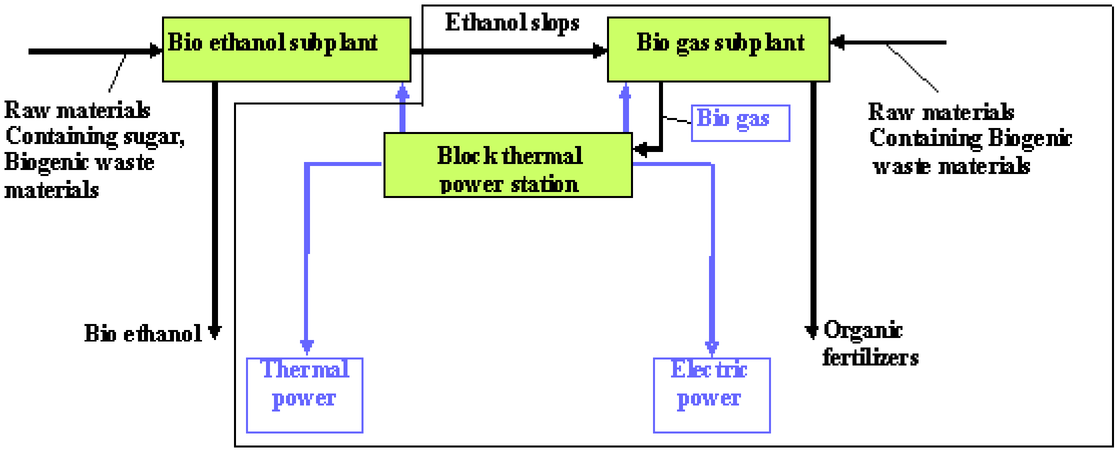

Fig 5-1: General technological structure of Bio power plant (Control subject)

The relationship between the disturbance amplitude and frequency on one hand and the dynamic properties of Bio power station on the other leads to the necessity of model and knowledge based on process control and maintenance. This control and maintenance must be cost-effective centralized for all Bio power plants of a carrier in one region. These circumstances require the use of heterogeneous networks.

Biogas-carrier benefits of centralized control of distributed technological plants using VAN – solutions are:

- Know-how of one operator or maintenance engineer can be used for the control of a great number of plants without time –delay
- Model based control system can be used for a great number of plants
- The costs of centralized control system can be divided by the number of decentralized technological plants
- Estimated benefit: 30 % raising of the profit

5.1.2 Requirements to the VAN solutions from the point of view of control and maintenance system in the process industry (Biogas power plant)

The functionalities of central control systems are:

- Model and knowledge based central control (process coordination, process stabilisation, securing control)
- Knowledge based maintenance

The general requirements to central control system with integrated VAN- solutions to be evaluated are:

- Real-time requirements
- Security requirements
- Safety requirements
- Provider switching of mixed wireless and wired public communication
- Scalability of security and real-time
- Guaranteed availability

5.1.3 Short description of the VAN Solution and Implementation for PA IES

The VAN IES for process industry consists of three parts:

- Central control and maintenance system
- System for communication between central and local control system
- Local control systems for geographical distributed biogas power plants

An HMI system “SIMATIC WinCC” is used for central control and monitoring of the decentred biogas sub plants in IES PA.

A knowledge based maintenance system is integrated as VAN maintenance system and supports service technicians.

Each of the systems, the visualisation system WinCC and the maintenance system SUI, contain special OPC-CBA-Clients to access data from the CBA Server of the local controller using IEC 61158 Type 10 - PROFINET CBA – protocols.

Fig 5-2 shows the integration of VAN Solution in the IES

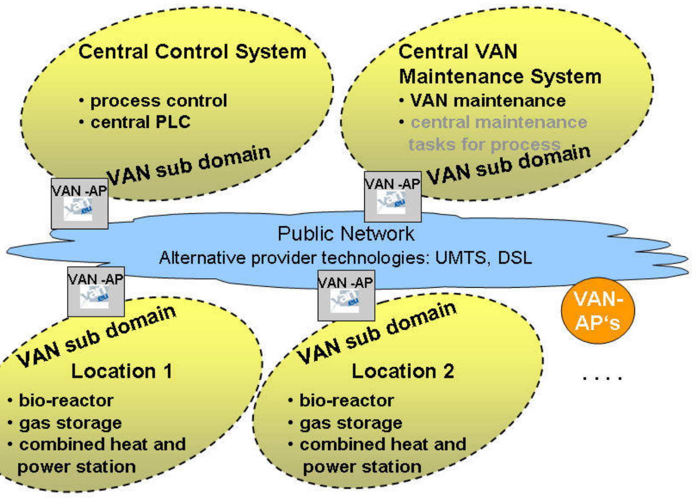

Fig 5-2: General Structure of PA IES

Because of optimising the handling of the IES the central components will be concentrated for the IES application in one location, the operator centre, and the local components of the decentralized biogas power plants will be located at one local biogas power plant. This is the PA IES specific version of central controlling of distributed biogas power plants as an example.

For the real IES implementation was selected an operator centre in Gera and an existing biogas power station in Neukirchen, both located in Saxony:

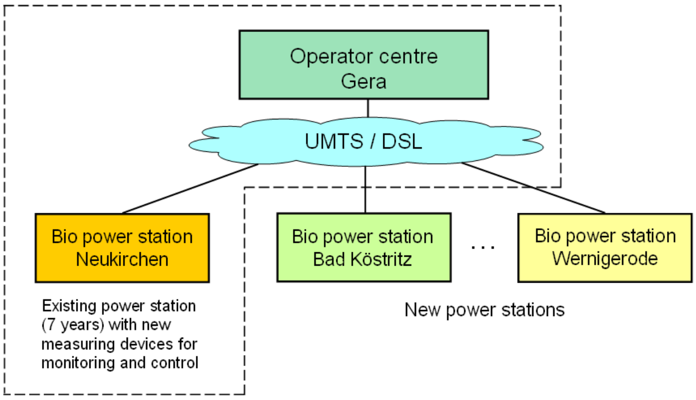

Fig 5-3: Operator centre at local biogas plants

Some other regional biogas power stations also need the advantages of the VAN technology in the future. The biogas company management selected the oldest plant because of needed technological improvements that will be applied by using the new VAN components.

The Process Automation IES contains the following technological components

- One biogas power plant with 2 controlled processes:
  - the biogas reactor, connected to the VAN communication system via local I/Os
  - the power plant with a local process controller (soft PLC)
- One central controller (hard PLC) in the operator centre for special control tasks
- One HMI-System in the operator centre (control supervisor)
- One maintenance-system in the operator centre (maintenance supervisor)
- One VAN connected PC station for VAN engineering functions.

For the setup, validation and tests of the VAN components will be used methods of control engineering. The creation of the IES for the process industry will be performed in two steps:

- Step 1:
  Test of VAN solutions using a partial simulated technological plants (Test system)
- Step 2:
  Integration of the test system VAN application in the automation network of the real technological plant and selective switching of real process into the VAN communication system

From the technological point of view the VAN based application provides the following features:

- Central supervisory of several decentralised local biogas power plants
- Central process control for selected control tasks or special algorithms for many decentralised stations with simple and cheap I/O units in the local stations only, without the necessity of any local controller

Central supervisory of the maintenance tasks for the connected local biogas stations, completed by a system for controlling and maintenance the VAN network it selves.

Fig 5-4 describes the general structure of the PA IES.

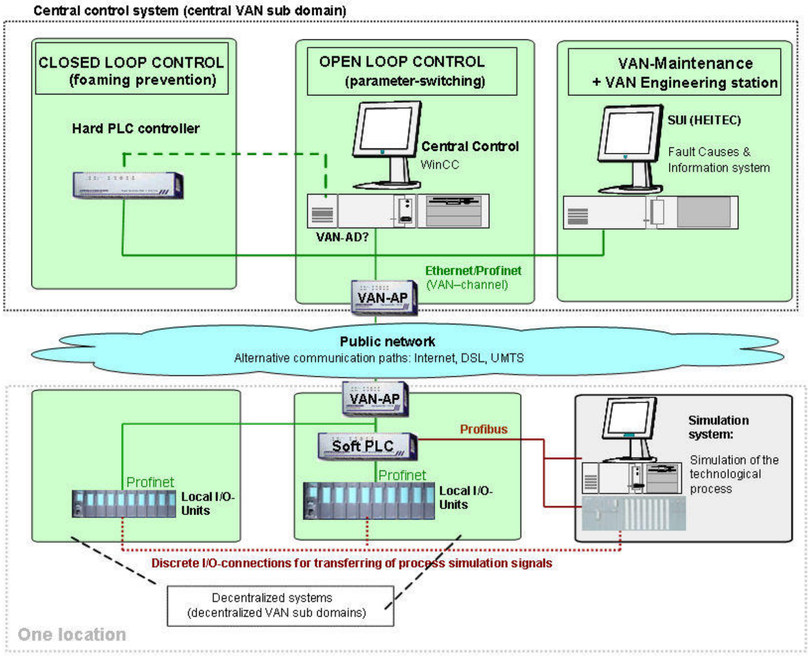

Fig 5-4: Integration of VAN solutions in the Process Automation IES including a simulated technological plant

5.1.4 Integration of VAN solutions in the parts of final IES-demonstrator

The PA IES implementation will be demonstrated on 2 locations, the operator centre in Gera and the biogas power plant in Neukirchen witch is in the status of regular production.

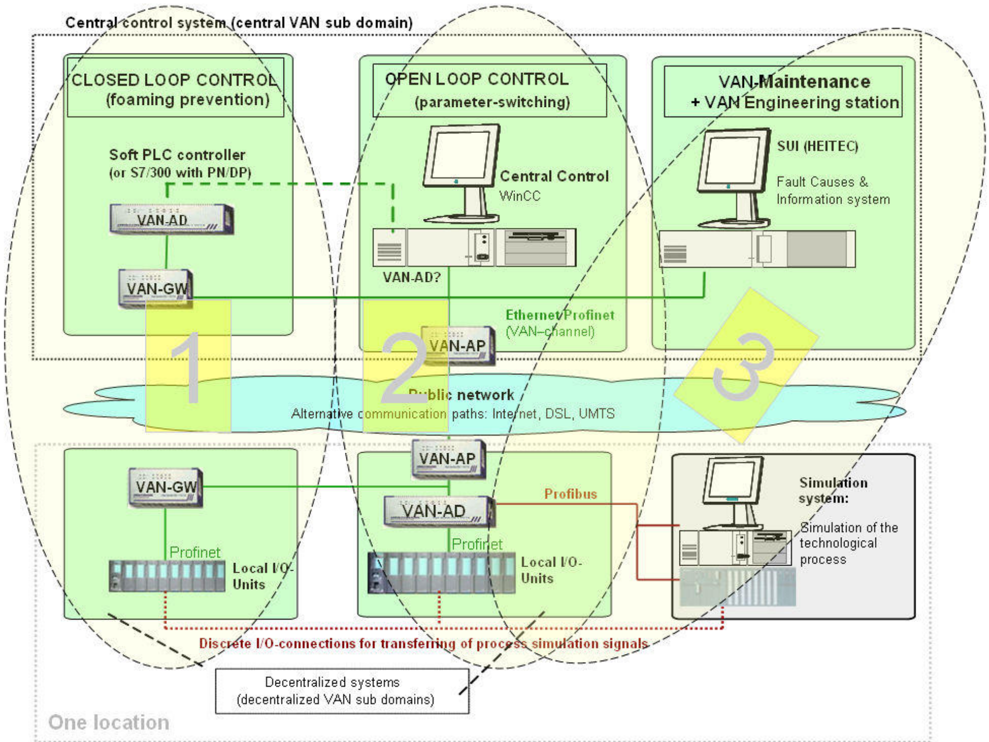

Fig 5-5: Main VAN use cases in the PA IES

The central control system of the PA IES covers 3 technological control tasks:

1. Bio reactor:
   - Process optimization: production of maximum biogas output and observing the reactor stability
   - Protection of the reactors biology against dangerous process conditions
   - Prevention of foaming inside the reactor
2. Gas storage and power station (CHP):
   - Optimal coordination of gas storage and power station (CHP)
   - Optimisation of set points for the performance of CHP
3. Maintenance:
   - Integration of a system for maintenance supervisory
   - Fault detection, observing important plant components
   - Monitoring and visualisation of VAN components and QoS –parameters

The PA IES contains separated VAN tunnel architectures for each of these tasks and will be completed by a VAN Engineering station.

5.1.5 Implementation of the Security by VAN Solutions

Industrial communications are made secure by means of OpenVPN tunnels, which are established in order to send information from one VAN subdomain to another, making use of encryption methods which guarantee security and allow seamless communications between networks interconnected to the VAN-APs (VAN Access Points).

The following figures shows the cascaded VAN tunnel structure used for experimental investigations regarding the reliability, availability and robustness of the established VAN communication channels.

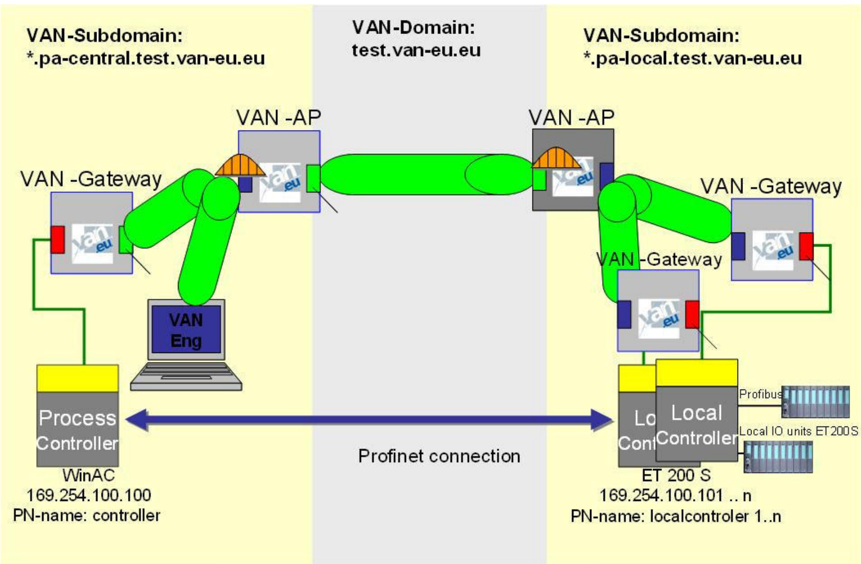

Fig 5-6: Cascaded VAN tunnel structure for PA IES Example 1

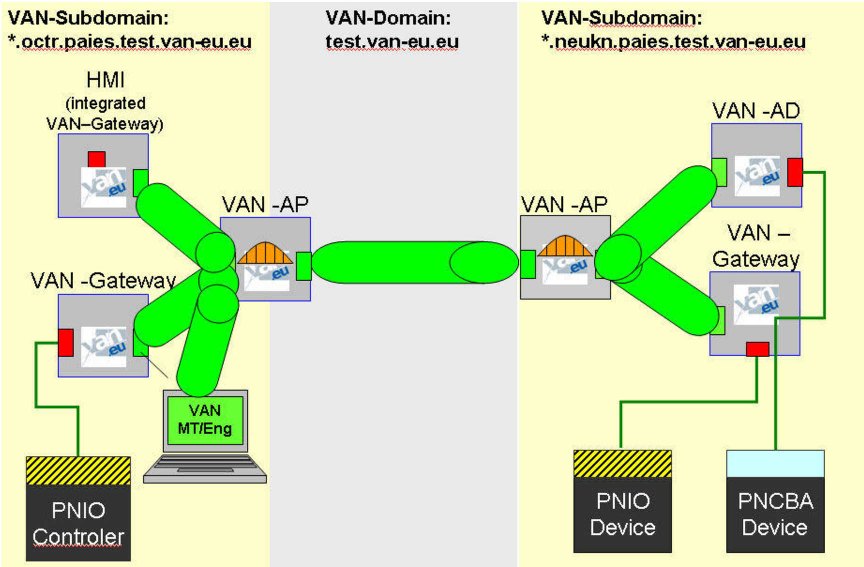

Fig 5-7: Cascaded VAN tunnel structure for PA IES Example 2

5.2 Manufacturing Automation Industrial Experimental Setup

5.2.1 Short Description of technological plant to be controlled and necessity of using VAN solutions

In the manufacturing automation usually an item requires various working stages for its completion; this situation is typical of an machining line, that could be described as a mechanical system whereby an item is conveyed through sites at which successive operations are performed on it; these operations are performed by manufacturing machines, while one or more robots are responsible for loading the items from a conveyor belt to the machines and vice versa.

The Factory Automation IES is made of

- Two manufacturing machines (one real and one simulated)
- A manipulator robot
- A conveyor belt,
- A remote PC station for safety and monitoring functions (safety supervisor),
- A remote PC station for management and coordination functions (control supervisor).

The manipulator robot (see Fig 5-8)will be in charge of removing items from the conveyor belt and load them on one of the manufacturing machines; the items will undergo a (simulated) process while in the machines then will be unloaded by the same manipulator robot.

Fig 5-8: Manipulator Robot

One or more safety devices will be connected to the VAN network in order to simulate the gathering of important signals; basing on these signals the safety supervisor will issue orders to the machining line devices to avoid any risky situation.

Also, the control supervisor will be connected to the network; its main task will be to modify the logical setup of the devices (coordination behaviour) and to be the repository for the parts designs.

It is worth noting immediately that the devices that will make up the low level of the machining line (machines, robot, conveyor, etc) will be part of different segments (company departments). Due to the fact that the exclusiveness on the network and the exclusive management is not given, every path over a network with changing responsibilities for the segments is a public network even if managed by the same company. This introduces a number of problems (typical of a public network) that must be overcome, namely bandwidth and low performance problems such as:

- Non exclusive access to the network,
- Sharing of the transmission channel

The high level control of the machining (that decides which part will be worked on which machine and the pallet transportation coordination) will be the main task of the remote control supervisor. This station will be located outside the factory and so the problems described above will achieve greater magnitude.

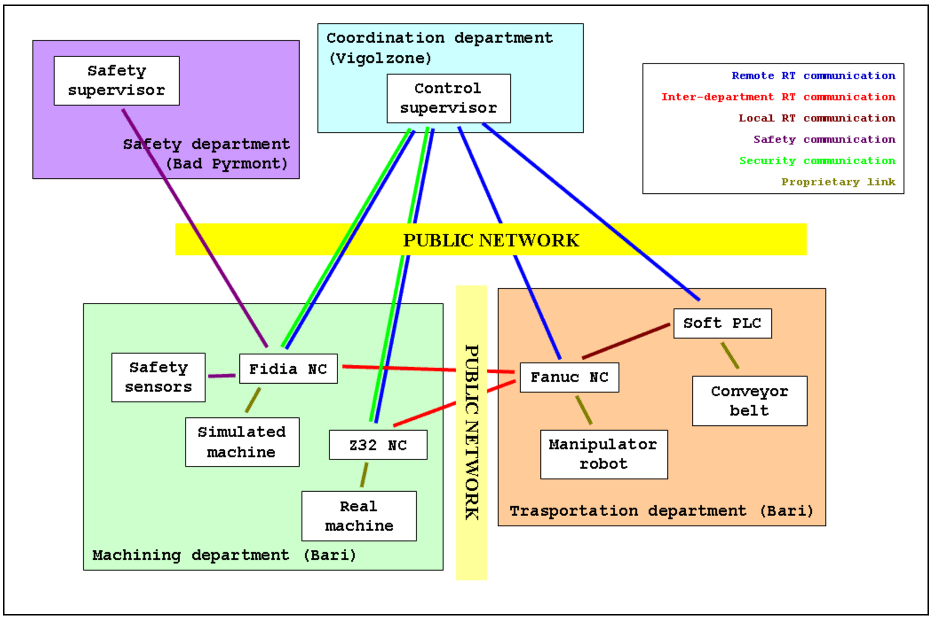

Fig 5-9: General scheme of the Manufacturing Plant

A properly functioning machining line requires:

- Fast (real-time) communication between the devices in order to properly coordinate them and to avoid any collision risks while performing various operations;
- Safety management: a great number of safety devices are integral part of the typical machining line; the signals coming out from these devices must be properly gathered and an adequate answer has to be provided in the shortest time;
- Security management: the data exchanged between the devices is often very sensitive and covered by copyright, therefore, any interception risk must be avoided.

5.2.2 Integration of VAN solutions in the parts of final demonstrator

5.2.2.1 Anti collision control

An anti collision system is necessary in order to guarantee that moving devices will not hit each other. In the case of the MA IES, it is needed for the manipulator robot and the drilling machine not to collide. Therefore this system has requirements dealing with real-time communication, as safety regarding the position of these devices has to be assured within small periods of time.

The real time application (anti collision system) will see an interconnected system in which the listed devices will be made VAN available by integrating VAN functionalities (when possible) or using VAN gateways. The devices for real time will be installed in Vigolzone and Modugno (Bari, Italy).

5.2.2.2 Safety control

In work package 5 of VAN project it was specified and selected that the PROFIsafe safety protocol fits best to the defined safety requirements on VAN heterogeneous networks. Therefore in WP5 it was not developed a new stack of a safety communication layer, but it was installed a system that enables VAN safety communication over heterogeneous networks using PROFIsafe. The system consists of one F-Host and several F-devices, which are connected via VAN communication architecture.

In order to enable the VAN communication over heterogeneous networks a so-called VAN AP IPC device is needed. This device is based on the VAN common prototype platform. The main task of the VAN AP IPC is to take the PROFIsafe frames and put them into an Open VPN tunnel.

The prototype is locally installed at one of Phoenix's locations in Germany. Here a robot test cell is used. This test cell will be also part of the VAN IES for factory automation. In this way, VAN safety communication can be demonstrated.

The robot test cell at Phoenix's also includes the wireless prototype. The PROFIsafe slave devices (so called F-devices) are installed at Fidia's location.

5.2.2.3 Secure Transfer

The VAN approach for secure, real-time communication over Inter-LAN, WAN and public networks is the use of a private VPN tunnel for moving the information generated by the CBA components. An established VPN Tunnel can be used to transport layer 2 protocols and thus enables the integration of existing real-time communication technologies which are using layer 2 addressing. Secure transfer of file will be shown using FTP protocol over the VAN extension of OpenVPN. Fig 5-10 shows how the ecure transfer is achieved by means of the tunnel:

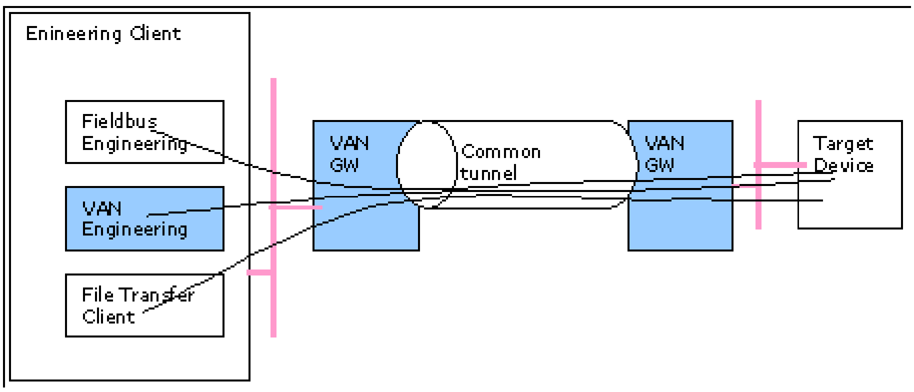

Fig 5-10: Secure Transfer by means of Tunnel