ARCHITECTURE FOR AUTOMATION AND TELEPRESENCE IN A MARINE HATCHERY LABORATORY

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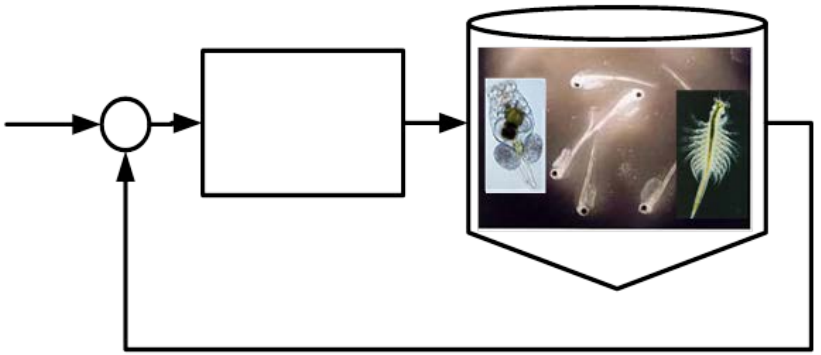
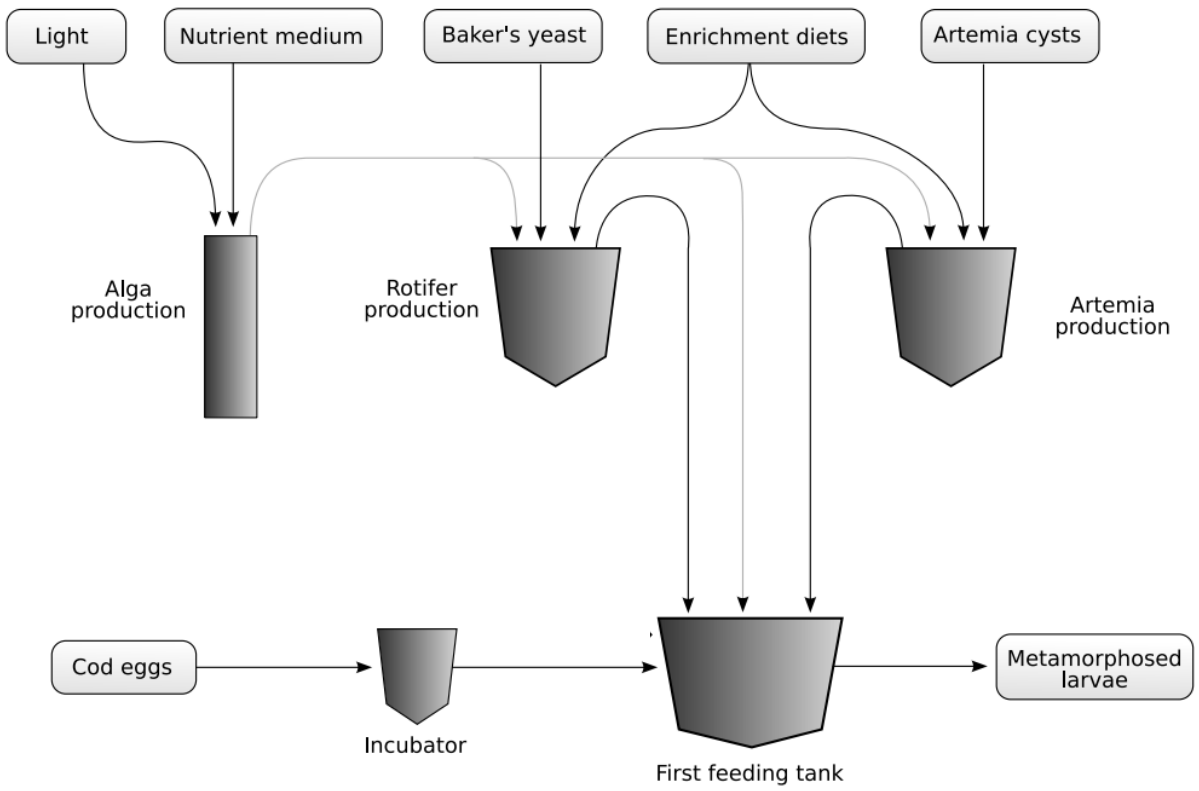
Outline

- Background - automation and marine larval and juvenile production
- The CodTech marine hatchery automation laboratory
- Development of an infrastructure for automation and telepresence in CodTech
- Lessons learned



Larviculture: A process-oriented perspective



+ Water management system
+ Climate control system
+ Hygiene and cleaning system

Production consists of a set of processes that are:

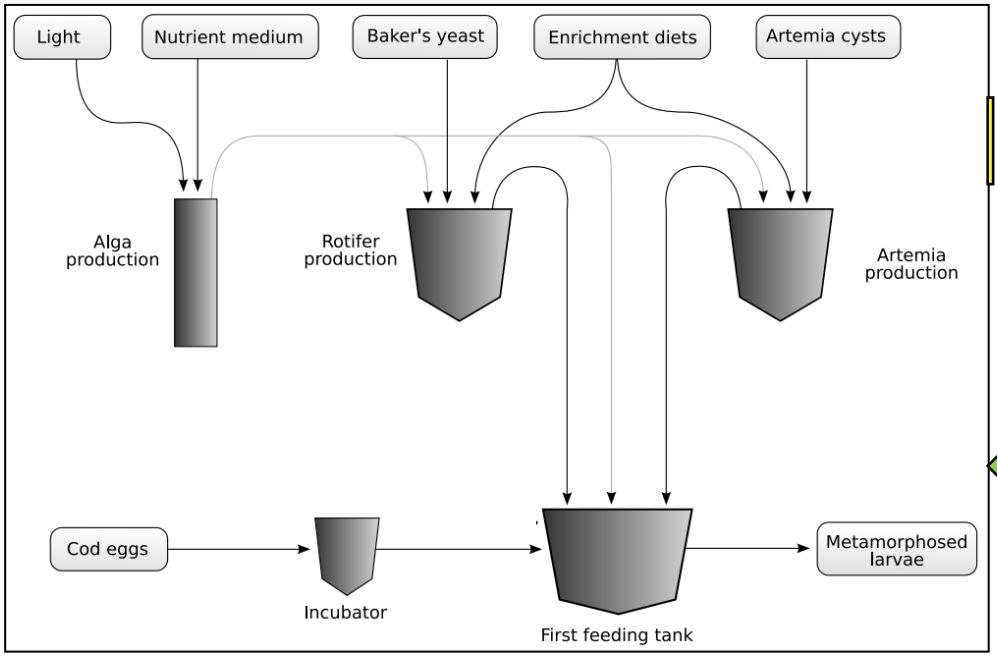
- dynamic
- interdependent
- asynchronous
- required to operate within certain limits and at certain rates

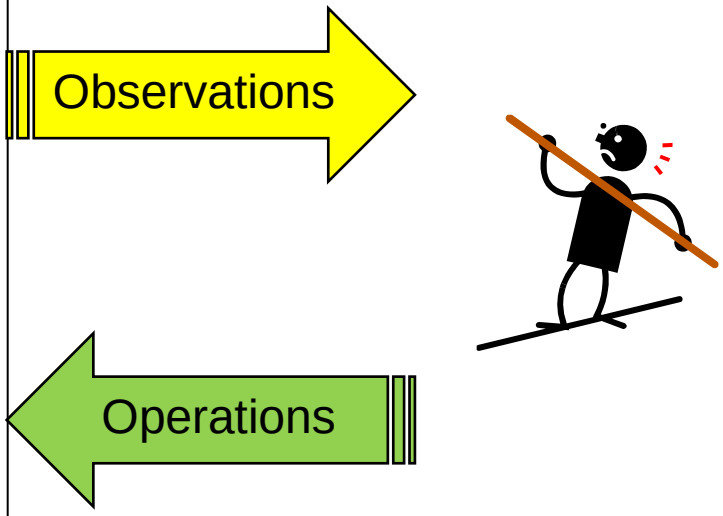
Production goals:

- Maximize fry quality
- Maximize capacity
- Maximize robustness
- Minimize costs
- ++

Controlling the production system optimally is a complex task.

What tools are there to help us?





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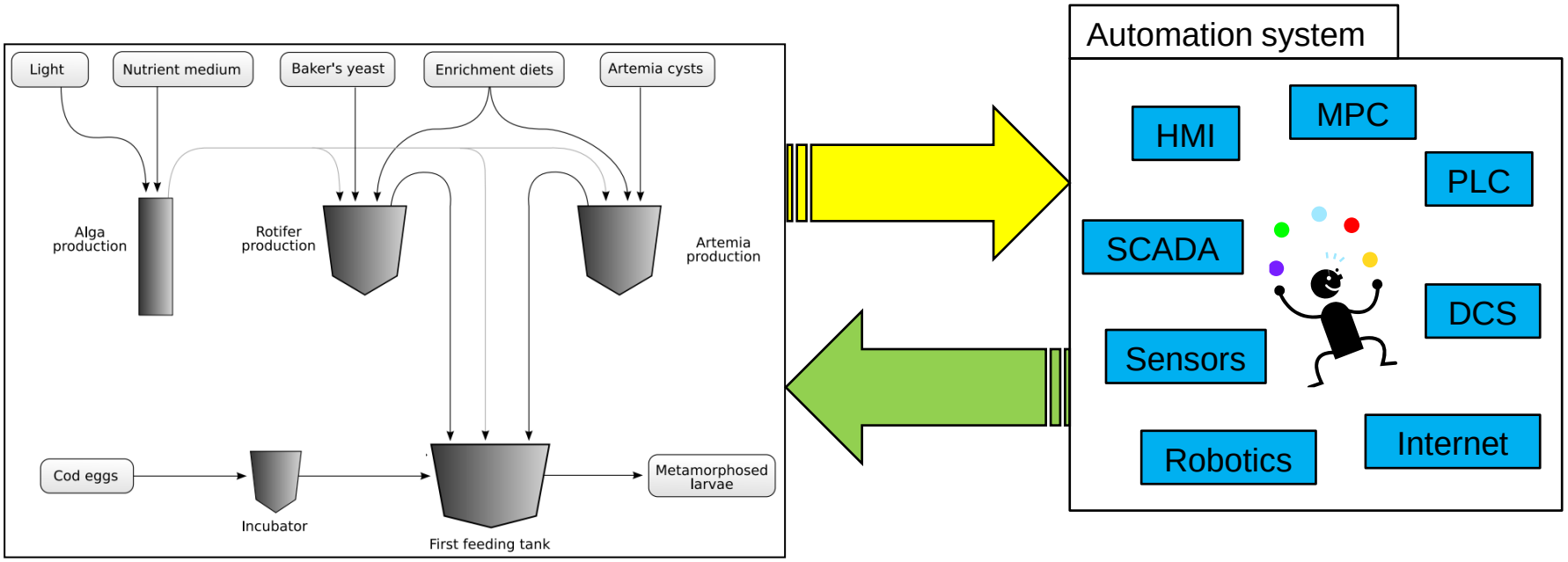
Automation

The collective use of machines, sensors, computers, ICT and automatic control to optimize capacity, quality, robustness and costs of a production process

- Automation is generic and one of modern society's "enabling technologies"
- Marine hatcheries should benefit from the lessons learned in other industries where automation is well established
- Traditional view of just saving labour costs is too narrow and must be abandoned
  - Accuracy and consistency in operations → quality and robustness
  - New modes of operation that are impossible to implement with manual labour
- Automation required to achieve productivity and quality goals when scaling up and industrializing marine hatcheries

Automation tools



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Challenges

Nevertheless, “larviculture specialities” must be kept in mind:

- Complicated biological processes
  - Process knowledge sometimes limited
- Product is live organisms
  - Careful handling, ethical issues
- Special instrumentation needs
  - Can it be measured in a practical way?
- Challenging environment
  - Delicate electronic equipment in a wet and corrosive environment

CodTech
- Marine hatchery automation laboratory

- Research on larval production protocols
- Initially designed for cod larvae production
- Test-bed for hatchery automation technology

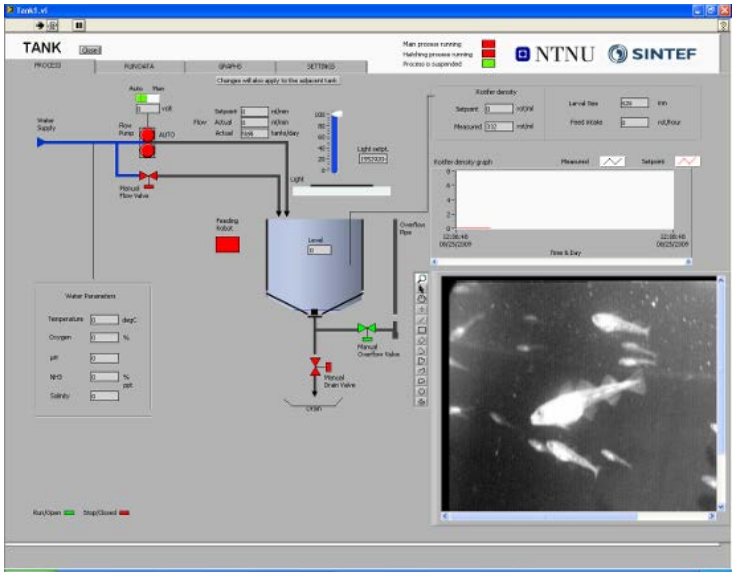
CodTech, NTNU Centre for Fisheries and Aquaculture

Laboratory sections

- Start feeding
  - 18 larval tanks
  - Robotic feeding
- Live feed production
  - 12 production tanks
  - Rotifers, Artemia, copepods, algae
- Water supply system
  - SW, fresh
  - Raw, matured, recirculated

First feeding section

- 18 tanks, V = 160 liters
- Feeding robot
  - 3 live feed silos, 2 dry feed silos
  - Automatic refill station
  - Feeding tables or feedback controlled appetite feeding
- Automatic live feed counting and logging
- Automatic live feed density control
- Water quality and flow monitoring and control
- Lighting control
- In-tank video cameras
- Lab floor video camera
- Network access



Integration issues

- System comprises a diverse set of equipment with:
  - different user interfaces
  - different communication interfaces
  - different modes of operation

→ No common point of entry

→ Communication between subsystems difficult

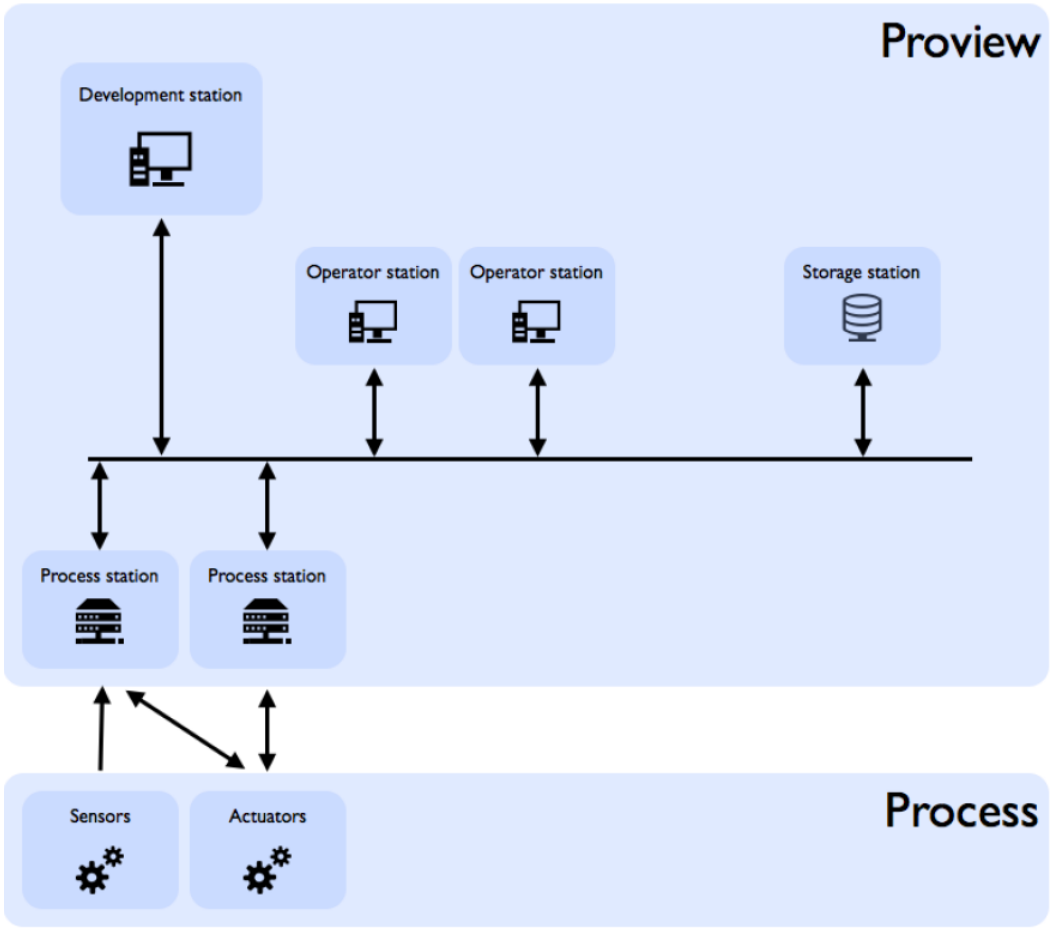
→ Confusing and inaccessible for the operator

→ Higher risk of doing errors

Solution for “gluing” subsystems together to form one coherent and user-friendly system needed

CodTech automation solution

- Based on Proview – open process control system
- Modular design
  - Development station
  - Process station
  - Operator station (HMI)
  - Storage station
- Open and extensible
- Flexible integration of many types of instrumentation
- Free…



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Remote access

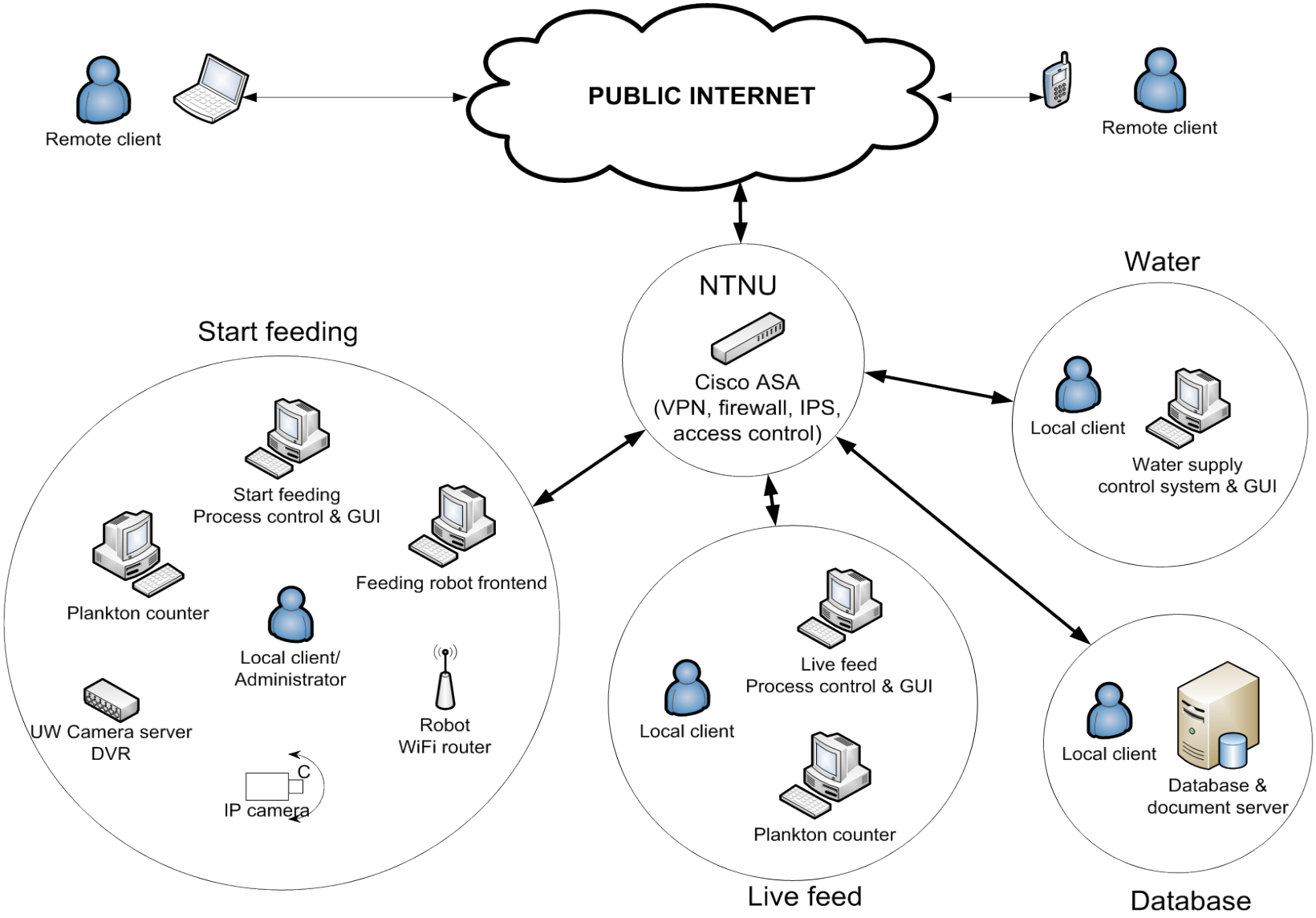
- Networked computers monitor and control an increasing number of laboratory tasks
- Makes remote access to laboratory resources over the Internet possible:
  - Real-time data always available
  - Closer follow-up of experiments
  - Adds flexibility to management of experiments
  - Telepresence

→ However, **security** needs to be handled carefully

- CodTech is part of the EU FP7 Capacities project AQUAEXCEL (Aquaculture infrastructures for excellence in European fish research, www.aquaexcel.eu)

- Supports transnational access to facility for guest researchers

- System for remote access and telepresence in CodTech facility under development to facilitate remote users
  - certain aspects of experiments may be followed up from “home”
  - remote real-time and historical data monitoring
  - visual feedback from the lab floor, from robot and inside tanks
  - use the feeding robot to “move around in the lab doing things”



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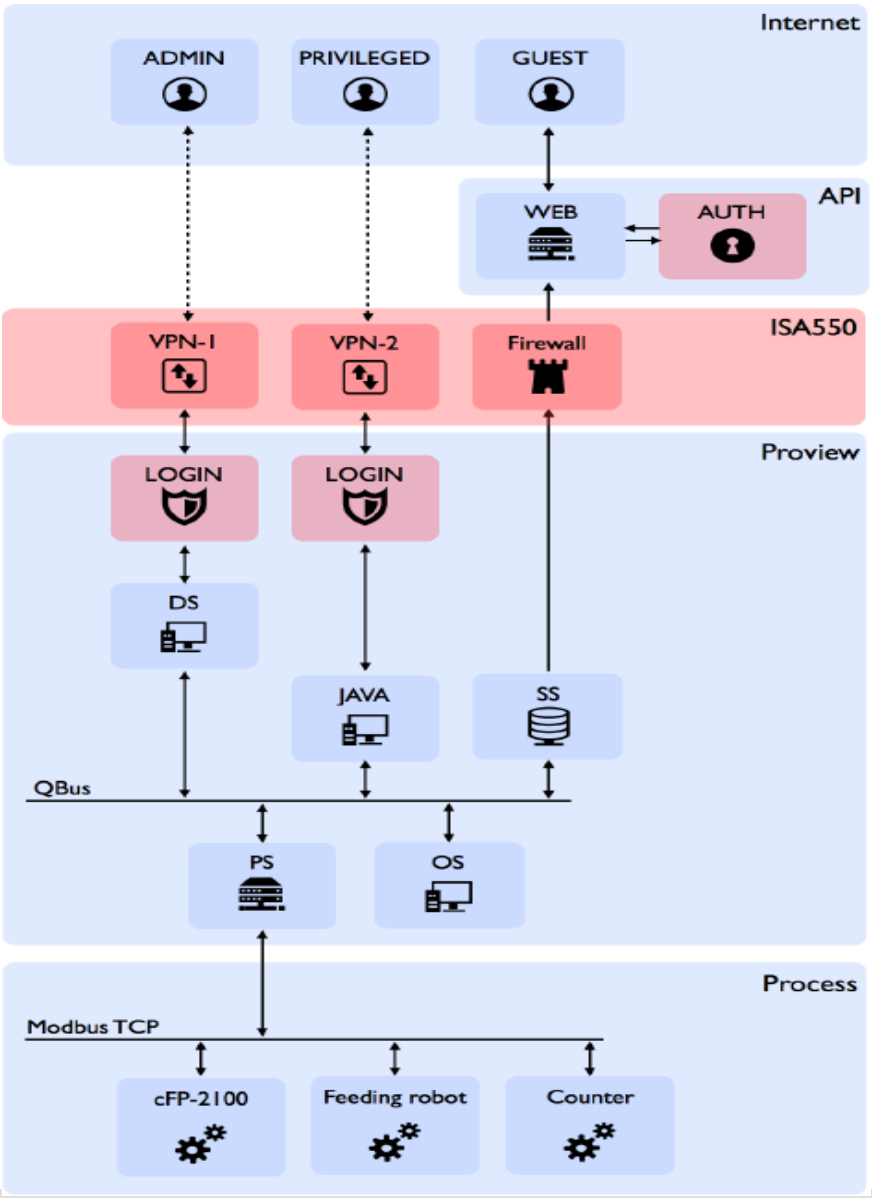
Architecture for remote access

Network security provided by:

- Physically isolating the automation network
- Forcing all access through a dedicated security appliance
- VPN login and firewall mechanisms
- Introducing user categories and privilege levels
  - Administrator
  - Privileged
  - Guest user



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Some lessons learned

- Designing an automation system ad hoc may lead to integration issues as it grows in size and when more advanced functions need to be implemented
  - You will eventually need a solution for tying everything together
  - Good solutions available, but design needs careful planning

- Requirements to the automation system can generally be divided in two categories
  - Standard requirements → solved by “of-the-shelf” components
  - Process-unique requirements → purpose-built instrumentation and control systems must be developed and commercialized

- The latter category demands
  - Resources to R&D
  - A strong and competent industry
  - Cross-disciplinary cooperation between biologists and engineers

Thank you for your attention