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Physical Infrastrucure for Digital Assessment

Best Practice Document

Produced by the eCampus digital exams working group on physical infrastructure.

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1 Introduction

Under the auspices of the eCampus programme, UNINETT has set up a project on digital exams. The project consists of several working groups and a steering group. The present document was produced by the working group on physical infrastructure.

Best practice documents (BDPs) have been developed to describe recommended solutions for digital exams in universities and colleges. The agreed solutions are based on the experiences of working group members.

The documents are intended as working tools for planning and preparing for the holding of digital exams, both in self-owned and rented (temporary) buildings.

The primary target group is technical staff and advisors responsible for the planning and holding of digital exams. The documents also give recommendations on how to ensure that the chosen solutions are based on and satisfy the real needs of the users, that is, of the students and lecturers.

The present document does not take a position on all the existing software solutions for digital exams. It will focus on infrastructure requirements, whereas requirements concerning software, servers, virtualisation solutions, firewalls, and surveillance systems follow from the chosen software solution.

1.1 Document structure

UFS 145: Physical Infrastructure for Digital Exams

This document contains recommendation for physical infrastructure in permanent and temporary halls used for holding digital exams.

Other BPDs in the series on digital exams:

UFS 146: Clients for Digital Exams

This document contains recommendations for clients used for digital exams.

UFS 147: Integrating Solutions for Digital Exams

This document contains recommendations for datasets and formats for data exchange between solutions for digital exams.

1.2 Recommended process

The work on preparing a room for digital exams should start well before the first exam is held. We recommend the following process:

1. Get an overview of the planned use of digital exams in the coming exam period.
2. Get an overview of the demands that the planned exam and chosen exam solutions will make on clients and on the network, power, lighting, and cooling infrastructure.
3. Draw up a schedule for use of the room. This is important if the room is shared between ordinary written exams and digital ones.
4. If the halls are rented, carry out an inspection visit to check the physical properties of the room.
5. Draw up a proposed specification for infrastructure in the room, whether it is to be a permanent installation, or an *ad hoc* installation for use in rented rooms. Clarify who is to bear the costs. This is particularly important for *ad hoc* installations that are less likely to be re-used.
6. Clarify the need for support during the time when the digital exams are held. Make sure that proctors and support staff receive the necessary training.
7. Procure network and power components as necessary.
8. Carry out the installation. For *ad hoc* installations, a test installation should be performed.
9. In an *ad hoc* case, clear away/disconnect the equipment and prepare it for re-use.
10. In an *ad hoc* case, evaluate the solutions and write down the lessons learned and possible improvements.

Note that these BPDs do not enter into questions concerning the procurement process itself, such as administrative and contractual provisions, the contracting process, tender evaluation, or operating and service agreements.

1.3 Changes in this revision

This is the first draft of this BPD.

2 Fundamentals

Part III offers some examples of infrastructure solutions for digital exams, with descriptions both for rooms with permanent infrastructure and rooms with *ad hoc* infrastructure.

The following chapters contain descriptions and requirements of infrastructure solutions for digital exams. For some of these areas, there are no applicable standards or concrete specifications, and the working group has taken existing specifications from other fields of the education sector and adapted them to the field of digital exams.

It is very important to describe the demands made on infrastructure by a chosen exam solution and software at an early date. It is also important to clarify as soon as possible whether the digital exams are to be held on campus or in rented rooms. The rigging of ad-hoc infrastructure in rented rooms may require hiring resources such as electricians, ventilation experts, and similar.

2.1 Digital classroom exams, with and without aids

The focus of this BPD is on digital exams that replace the traditional pen-and-paper-based written in-class exam. It covers written exams with and without aids.

2.2 Delimiting the topic

The focus of this BPD is on infrastructure for digital exams. Workflows for digital exams and client requirements for digital exams are dealt with in separate BPDs.

The document aims to support several different digital exam solutions, and therefore does not discuss details of software, servers, virtualisation solutions, firewalls, and surveillance solutions.

Infrastructure solutions to support oral exams or take-home exams with digital tools are not dealt with in this BDP. However, parts of the specifications and tools can also be used in connection with other examination forms than written digital in-class exams with proctors present in the room.

2.3 Physical requirements

2.3.1 Space

There is no (Norwegian) national standard governing the allotment of space per examinee in the examination room. The local examination offices at different institutions relate to local rules. Typical figures range from 3.5 to 5m^2 per examination seat, depending somewhat on the size and shape of the room. Digital exams pose new visual privacy problems, and hence require greater distance between examinees taking the same exam. It may be practical to mix the examinees according to a set pattern so that no two examinees sit beside each other or behind each other in the same row.

2.3.2 Power

Power consumption differs between the different types of client. In the planning phase, one must take into account that the examination room may be used with all kinds of client. When desktop PCs are used as clients, each examination seat must be equipped with two sockets. In other cases, one socket per seat will suffice. With ad-hoc infrastructure solutions, it is important that the power distribution scheme comply with regulations for electrical installations.

The following figures may be used to budget power consumption:

Client type	Power consumption budget	Number of clients per 10A circuit	Number of clients per 16A circuit
Desktop PC with screen	200W	10	15
Laptop PC	100W	20	30
VDI client	50W	40	60
Tablet	15W	100	150

Table 2.1: Budget figures for power consumption

When laptop PCs are used as clients, we may expect each client to supply as much heat as the number of people in the examination room. Typically, one must assume 100W of power consumption per examinee. This may seem excessive for modern equipment, but one has to take into account the additional power going to charge the computer battery. In an average-sized room with 100 examinees, this may mean up to 100kWA of additional heat. This may trigger additional ventilation and cooling requirements, or require the number of examinees to be limited to a number that does not raise the temperature excessively.

The Norwegian Labour Inspection Authority, in its guidance document on climate and air quality in the workplace ("Veiledning om klima og luftkvalitet på arbeidsplassen" [1] sets out the following standards for workplace temperature:

> In seasons with a need for heating of the working areas, it is recommended that the air temperature in the workplace be kept below 22° C. One must seek to provide the option of individual regulation.
>
> Operative temperature (see What affects experienced temperature) beyond the following ranges may be grounds for requiring measures to be taken:
>
> | Activity group | Light work | Medium work | Heavy work |
> |---|---|---|---|
> | Temperature ° C | 19 - 26 | 16 - 26 | 10 - 26 |
>
> The workplace must if necessary be shielded against heat radiation (sun, thermal processes) and against cold surfaces (radiative heat loss).
>
> Heat stress makes people less attentive and is a risk factor in work that requires watchfulness.

2.3.3 Air

A digital exam does not in itself trigger additional ventilation requirements, but increased ventilation may solve temperature problems caused by numerous client devices and additional power consumption.

The following extract is from the Norwegian Labour Inspection Authority's "Guidance on climate and air quality in the workplace" [1], which sets out the following standards for workplace ventilation:

> **Ventilation**
>
> Ventilation must be assessed according to needs. The minimum acceptable air supply in new buildings or after extensive renovation is determined as the *sum* of the following:
>
> Human air needs: 7.0 l/s per person
> Airing of materials: more than 2 l/s per m² floor
> Addition for processes and activities: (1 l/s = 3.6 m³/hour)
>
> High temperatures increase evaporation from construction materials, and the air is experienced as dry. Therefore, more air must be supplied if the air temperature cannot be kept at no more than 22°C in winter. Ventilation of materials must also be increased when using materials that emit or store odours, and where venting through windows is not possible. With normal use of materials, a reasonable supply is 2 l/s per m² of floor area; when using carpeted floors without well-organised cleaning or when using materials

posing particular air pollution risks, higher values than 2 l/s per m² of floor should be applied.

Draughts
Draughts or local cooling can result from a combination of air velocity and temperature or radiation to cold surfaces. If the air temperature is low, air movement is easily experienced as a draught. Air supply should be planned so that the velocity in the occupied area does not exceed 0.15 m/s during light work.

Carbon dioxide

High CO_2 content is due to inadequate ventilation given the number of people in the rooms. Satisfactory ventilation results in concentrations below the 1000 ppm standard.

2.3.4 Lighting

The Lyskultur publication "1B Luxtabell and planning criteria for indoor lighting" (*1B Luxtabell og planlegging av innendørs belysningsanlegg*) , March 2012 edition, gives recommendations and advice on the planning of lighting systems and explains the main terms in use. The publication is a guide and a complement to the European standard EN 12464-1:2011 Light and lighting – Lighting of work places – Part 1: Indoor work places.

The following table is taken from Lyskultur's HSE course on workplace lighting [2]

Function/visual task	EM lux	UGRI	Ra	EN-12464-1
Reading/writing/use of PC	500	19	80	5.3.2
CAD work	500	19	80	5.3.4
Technical drawing	750	16	80	5.3.3
Meetings	500	19	80	5.3.5
General illuminance of surrounding areas, continuous use	200		80	4.3.1

Table 2.2: Lyskultur's recommended light levels for indoor workplaces

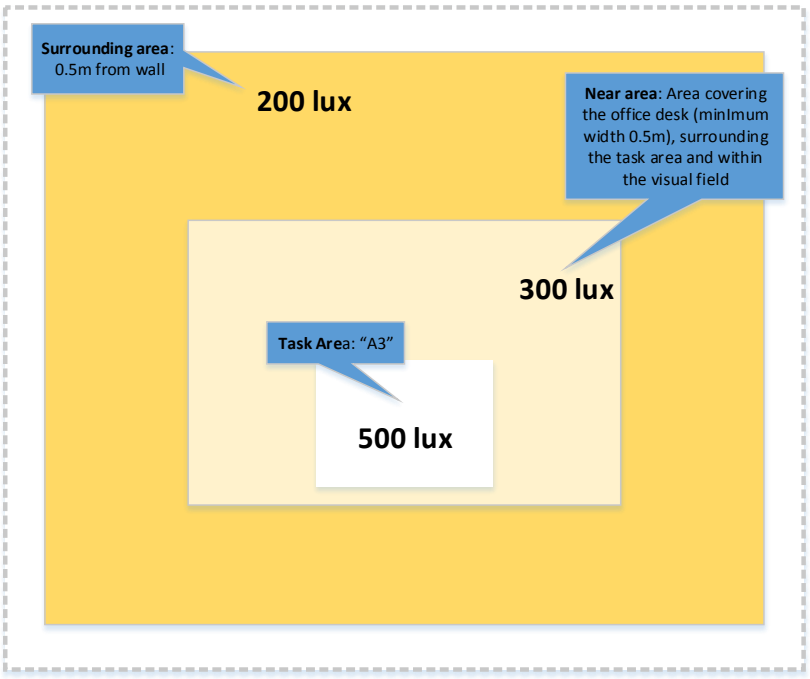

Figure 2.1: Lyskultur's recommended lighting levels for the workplace.

2.3.5 Bandwidth

When calculating bandwidth needs for the examination hall, it is very helpful if the digital-exam solution providers supply figures for bandwidth need per examinee. The contents of the exam and the choice of task type will affect the bandwidth needs; tasks involving use of video will involve greater needs than plain text.

The network traffic will wax and wane, with the heaviest traffic when the examinees start their exams, and in the finishing phase. During the exam, the traffic will be somewhat lighter.

The following figures may be used for budgeting bandwidth (uplink):

Client type	Typical client connection capacity	Number of clients per 100Mbit uplink	Number of clients per 1Gbit uplink
Desktop PC (wired), open exam	1Gbit	50	250
Desktop PC (wired), closed exam	1Gbit	100	500
Laptop PC (wired), open exam	1Gbit	50	250

Laptop PC (wired) closed exam	1Gbit	1000	500
Laptop PC (wireless) open exam	802.11ac up to 866Mbit	50 per base, 2 bases minimum	250
Laptop PC (wireless), closed exam	802.11ac up to 866Mbit	50 per base, 2 bases minimum	250
VDI client	100 Mbit	25	200
Tablet	802.11n up to 160Mbit	50 per base, 2 bases minimum	250

Table 2.3: Uplink bandwidth – budgetry requirements

2.3.6 Wireless keyboards/mice

Wireless keyboards and mice pose an administrative problem and raise some security issues that cannot be controlled in any simple way. It is recommended to establish a policy that students wishing to use wireless keyboards and mice must apply for such use, and be placed in separate areas/rooms where the proctors have been trained to spot the problems with wireless keyboards and mice.

Wired keyboards and mice do not pose a similar problem and may be permitted for use in the examination hall.

2.4 Universal design (adaptive solutions)

For digital exams, the design of the halls, the infrastructure, and the chosen technical solutions should take into account the diversity of the student body. This applies in particular to students with disabilities.

The Norwegian Act relating to Universities and University Colleges Act § 4-3 obliges these educational institutions to design the physical learning environment based on the principle of universal design, and to adapt the learning situation to students with special needs. The universal-design obligation also applies under the Anti-Discrimination and Accessibility Act §13, whereas §17 of that Act provides for the right of students to appropriate individual adaptation of the institution, teaching, teaching aids and exams, in order to ensure equal opportunities in training and education.

Both Acts recommend universal design as a strategy, here in the sense of designing the physical surroundings and technical solutions in such a way that they can be used by the greatest possible number without need for special adaptation or individual accommodation. The design must not prevent use of assistive technologies.

The Planning and Building Act requires buildings for work and public use to be universally designed (§ 12), and this applies to the physical design of access roads, buildings, and halls.

To ensure universal design of physical infrastructure in connection with digital exams, the infrastructure must be dimensioned based on people with different abilities. In this connection, that means impaired strength and mobility, impaired vision and impaired hearing.

Access to the halls is best ensured by complying with the requirements in the Regulations on technical requirements for building works (TEK10) and accompanying regulations, and the standard NS11001: Universal design of building works – Part 1: Buildings open to the public. This relates both to parking, entrance areas, and navigation through the building toward the examination hall.

Concerning rooms and other areas for people in buildings, the following provisions, among others, apply:

- Dimensions, designs, lighting, and acoustic conditions shall be designed so as to enable equal participation.
- The entrance shall be free of steps and have a turning space with a diameter of at least 1.5 metres. Wheelchair users shall be able to perform necessary functions.
- The reception and notice board shall be centrally placed, and both counters and the examination hall must have a system for assisted listening (technical hearing aids such as telecoils or similar). Fixed installation of technical hearing aids should be considered in regularly used examination halls.
- Every floor shall have at least one bathroom compliant with universal-design requirements.
- Signs and markings shall be easy to read and understand, and there shall be sufficient lighting to achieve a luminance contrast of 0.8 between text and background colour. Floor numbers shall be both visual and tactile. Dazzling lighting shall be avoided in communication routes.
- All auditory information shall be supplemented with visual information.

The required physical space to be allotted per examinee in the examination hall (cf. ch. 6.1) should be dimensioned based on a class A or B electric wheelchair, which should be able to manoeuvre freely between the rows to a suitable place. The recommended passage space is at least 1.2 metres, and the sum of widths in a 90-degree turn (toward a workstation) must total at least 2.3 metres. In a permanent examination hall, at least 5% of the desks should have adjustable height (up to a standing position). Where this is not possible, an alternative examination hall should be considered.

An adjoining break room should be considered.

Regarding lighting of the workstation, the requirements in NS 12464 and the applicable LUX table apply. For visually impaired students, screens must not cause reflection or glare.

Some students will require special technical equipment and software that is bulky (video magnifiers, refreshable braille displays) or noisy (speech synthesisers). In such cases individual measures should be considered, possibly including a suitable alternative examination hall.

2.5 Permanent infrastructure

The costs of having rooms permanently set up, and hence capital tied up, must be weighed against the costs of holding exams with the students' own equipment.

To make the most efficient use of the halls, digital exams should make as little demand as possible on infrastructure changes between exams. This means that exams that require distribution of various applications, special network access, and similar, should be dealt with as special cases and should be avoided as far as possible.

- Rooms permanently dedicated for exam use
- Terminal rooms/computer halls
- Equipped with desktop computers/"all-in-one" computers with large screens
- All devices are on a wired network

Advantages

- Quality controlled by the institution, set up and ready.
- Exams are easily planned, as the room is only used for exams.
- Can take ergonomics and HSE into account, computers can be equipped with a good keyboard and a good screen.
- Stable network.
- Less IT staff required for holding exams.
- Cheating is harder with controlled equipment.

Disadvantages

- The room is dedicated to exams, with limited possibility for re-use.
- Ties up floor space and capital.

One option is the use of a dedicated large hall, where the students use their own equipment; this will reduce the needed investment in computers, compared with the case where the room is equipped with desktop computers.

2.5.1 Test environment

Regardless which infrastructure solution is chosen, it is important to set up a test environment where students and staff can test the chosen solution for digital exams.

When the choice falls on letting students use BYOD for the exam, one must also produce a "test exam" that students can use to test that the chosen exam solution is compatible with their hardware.

2.6 Infrastructure for desktop computers

A desktop computer with a large screen, set up by the institution, permanently set up with:

- Screen, usually between 20” and 27” in size
- Ergonomically correct full-size keyboard
- Ergonomic mouse
- Updated software

Advantages

- Cheap equipment compared to laptops
- Quality-controlled by the institution
- Uses a wired network, so it is easier to control access to external information sources (internet)
- Takes HSE into account, with a large screen and good keyboard

Disadvantages

- Cannot be moved
- Expensive if one has to purchase a great deal of dedicated exam equipment, which ties up capital, and cannot realistically be scaled up to cover the need for computers for digital exams

2.7 Infrastructure for BYOD (laptop computer)

For exams where one wishes to use BYOD equipment, it is important that the exam has a form that requires only minimal installed software: ideally speaking, just a wireless network (cf. UFS 112) and a working browser. It is preferable for the exam to be limited to use of a “LockDown Browser,” or to solutions employing VDI, which only require a simple client to be installed.

2.7.1 Requirements for use of BYOD

- Initially limit BYOD to Macintosh and Windows laptops.
- Have an adequate service and support apparatus standing by, so that students can get help if the equipment is not working.
- In the beginning, one has to expect a considerable need for borrowing equipment. It is recommended that at least a 10% reserve of spare equipment be purchased.
- Require proven compatibility with the eduroam wireless network (cf. UFS 127)
- Equipment that keeps starting and stopping the network interface to save power, or similar, should not be used.
- Require updated drivers on the computer.
- Require BYOD equipment to have the appropriate keyboard or language, e.g. Norwegian or English. Otherwise, borrowed (spare) equipment must be used.
- Require the computer to have an appropriate version of the operating system.
- Require the computer to have an appropriate version and type of browser, compatible with the software used for holding exams.
- Draw up a proposal for recommended equipment.

- Get a signed statement from the student that his/her own equipment has been verified, that eduroam works and that a test exam has been held without problems.

2.8 VDI infrastructure

In a Virtual Desktop Infrastructure (VDI), the examination halls will be equipped with "dumb" terminals (screens, keyboards and mice), while all software runs on a central setup; be it locally on campus or on a shared national resource.

It is also possible to use the students' own PC or Mac (BYOD) in a VDI solution, but this complicates the solution and places greater demands on the competence of proctors and exam support staff.

Typical properties/advantages/disadvantages of dumb terminals:

- Screen, usually between 18" and 24" in size
- Ergonomically correct full-size keyboard
- Ergonomic mouse
- Updated software

Advantages

- Cheap equipment compared to laptops
- Simple administration of the clients, no need for large software-update jobs
- Uses a wired network and central computer resources, so it is very easy to control access to external information sources (internet)
- Takes HSE into account, with a large screen and good keyboard

Disadvantages

- Can be moved, but depends on wired infrastructure
- Expensive if one has to purchase a great deal of dedicated exam equipment, which ties up capital, and cannot realistically be scaled up to cover the need for computers for digital exams

2.9 *Ad hoc* infrastructure

"*Ad hoc*" infrastructure refers to an infrastructure that is not permanently installed. It may be an extension of existing infrastructure on the premises, or infrastructure that is installed on premises that are only temporarily used for exams (gymnasiums, sports halls, and similar).

2.9.1 On-campus halls

Most institutions have a number of halls that can be used for digital exams. The common denominator is that these halls are not equipped with permanent infrastructure for digital exams, and there will be combinations that do not allow the installation of permanent infrastructure in these halls.

- Classrooms, reading rooms, and canteens, for example, can be used to hold digital exams
- Presupposes that the rooms are furnished with tables and chairs
- The room must be rigged for power, perhaps temporarily for exam purposes
- Presupposes that a wireless network has been permanently set up and has sufficient capacity.

Advantages

- The exam will take place on campus; no need for network connections to external premises
- Necessary infrastructure such as power and cabling can partly be pre-installed
- Many rooms available.

Disadvantages

- Takes some work to make ready for exams.
- Scheduling can be demanding if the room is used both for exams and teaching
- Difficult to take sufficient account of ergonomics
- Holding a BYOD exam requires extra hardware and personnel resources

2.9.2 Large halls, gymnasiums

Digital exams may be held in large halls or gymnasiums that are rigged for digital exams. Here, the student will use his/her own computer (BYOD). Since it takes much work to set up a large hall, it should stay rigged for as long as possible.

Advantages

- Can be done large-scale, economies of scale, personnel per examinee can be reduced

Disadvantages

- Requires a great deal of infrastructure that has to be rigged: networks, power, chairs, and tables. If the large hall is off-campus, sufficient network capacity and power must be made available on the premises.
- Taking care of ergonomics and HSE can be difficult; noise can be a problem.
- If a large hall is rented off-campus, distances could pose challenges for the administration of exams.

If a large hall is to be used, it should be large enough to exploit economies of scale. As many digital exams as possible should be held in the same place. A hall large enough for 200+ examinees is recommended.

2.9.3 Lecture halls

Since the design of lecture halls makes it difficult to get in and out of seats without disturbing a neighbour, the use of lecture halls is not acceptable for short BYOD-type digital exams. The lecture hall must be equipped with adequate power and network (wireless).

The design of the lecture hall must be considered in the planning phase. In some lecture halls, for example, it will be impractical to use more than every third seat in every other row for exams. If the lecture hall has 200 seats, one could seat anywhere from 40 to 50 examinees in the hall.

2.10 Need for spare equipment

There will be a need for spare equipment during exams, but the extent of the need is unknown, and there is little experience from the pilots. The pilots were run on institution-owned equipment of good quality, and little equipment has failed.

- For desktop computers owned by the institution, the spare-equipment factor should be 5%
- For laptop PCs owned by the institution, the spare-equipment factor should be 5%
- For BYOD equipment for students, the spare-equipment factor should be 10%

2.10.1 Training needs

- Hold workshops in advance
- For BYOD-based exams, a solution could be set up for testing whether the students' equipment qualifies.
- If the student does not possess a suitable computer and has to borrow one, consider placing all students' borrowing computers in a suitable room. Distributing borrowed devices in examination halls takes a good deal of work.

2.10.2 Competence at using the solution

- Make an open test exam permanently available, so students can test the equipment in a setting as similar to a real exam as possible.

2.10.3 Support

- One must set up a support apparatus to which the student can turn if the equipment fails to work.
- Have competent IT staff available before and during the exam. A hotline can be an alternative if dedicated personnel cannot be available in every room.
- Have spare equipment ready if BYOD equipment doesn't work.
- Consider having another wireless network available in addition to eduroam. This network should have simpler authentication, e.g. WPA2/PSK.

2.10.4 Fallback solutions (redundancy)

The need for fallback solutions in connection with digital exams is bigger and more extensive than for written in-class exams. The costs of fallbacks for ad-hoc infrastructure in large off-campus halls can be very high. The need for a fallback solution and the costs of the chosen fallback should be documented.

- Power supply for the building and the examination seats
- Network connection for the building and the examination hall
- Network for the examination hall, fixed vs. wireless
- Spare hardware for exams
- eduroam vs. simpler net access
- Feide vs. alternative authentication
- DNS
- Implementation solution (electronic vs. paper)
- Solutions for handing in work (printouts, memory sticks, and similar.)

2.10.5 Maintenance window (maintenance day)

One must take into account that digital exams will take place throughout the year, and that in exam periods exams will take place from 9am to 9pm (two exams per day in the examination hall).

It will be necessary for the institution to define a regular maintenance window (day) in agreement with the infrastructure provider and the exam-solution provider. If several solution providers for digital exams are chosen, the maintenance window should be coordinated with all the providers.

One solution might be to follow Microsoft's update schedule and use the Wednesday following Microsoft's "Patch Tuesday" as the maintenance window, that is, to set aside the second and fourth Wednesday of every month for maintenance of infrastructure and exam solutions.

2.11 Security

2.11.1 Wireless network security

Wireless network security is described in UFS 112, and wireless networks used for digital exams should comply with the security recommendations for the internal zone in UFS 122.

2.11.2 Risk and Vulnerability Assessment

A Risk and Vulnerability Assessment of the chosen exam solution and infrastructure for digital exams must be carried out.

2.11.3 Visual privacy

Demand for visual privacy measures will increase; whereas paper lies flat on the table, screens stand upright, and some students may need to enlarge text, which makes it very easy to see from the neighbouring table.

Visually impaired students may be placed at the back of the hall, so that others cannot peek at their screens, which often feature enlarged text.

The biggest problem is with exams held on desktop computers, which often have large screens, from 19 to 24 inches. One could consider installing a 3M privacy filter, but this is expensive (at up to NOK 3,000 per screen).

The simplest approach is to reduce the capacity of the hall, or to mix examinees from several exams in the same hall, so that neighbours do not take the same exam. It is also possible to seat examinees further apart than one usually does in paper-based exams.

3 Examples of Infrastructure for Digital Exams

Given below are some examples of halls and infrastructure for digital exams.

3.1 Solutions with permanent infrastructure

Sketch of a solution for permanent infrastructure in seminar rooms, classrooms, and lecture halls.

3.1.1 Seminar rooms, classrooms

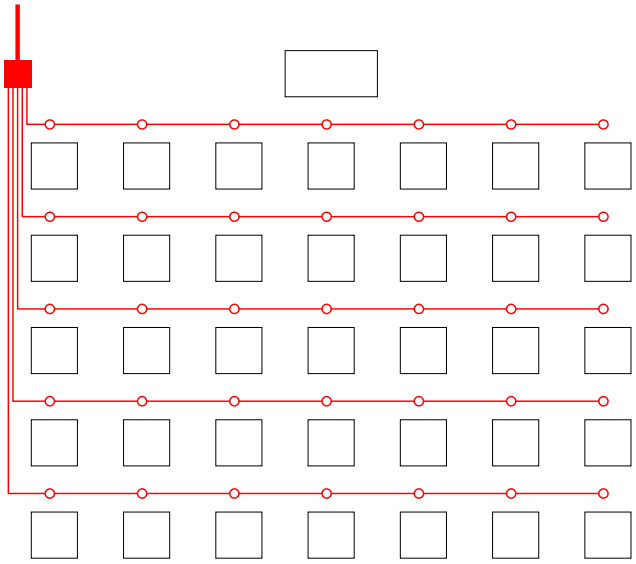

Figure 3.1: Sketch of a solution for power distribution in small seminar rooms and classrooms.

3.1.2 Lecture halls

Modern lecture halls are often equipped with power outlets for every other seat, and often have very good wireless coverage. It is not an ideal situation, of course, but it should be possible to use a lecture hall for short BYOD exams, e.g. two-hour exams.

The design of the lecture hall must be considered in the planning phase. In a given lecture hall, for example, it will not be practical to use more than every third seat of every other row for exams.

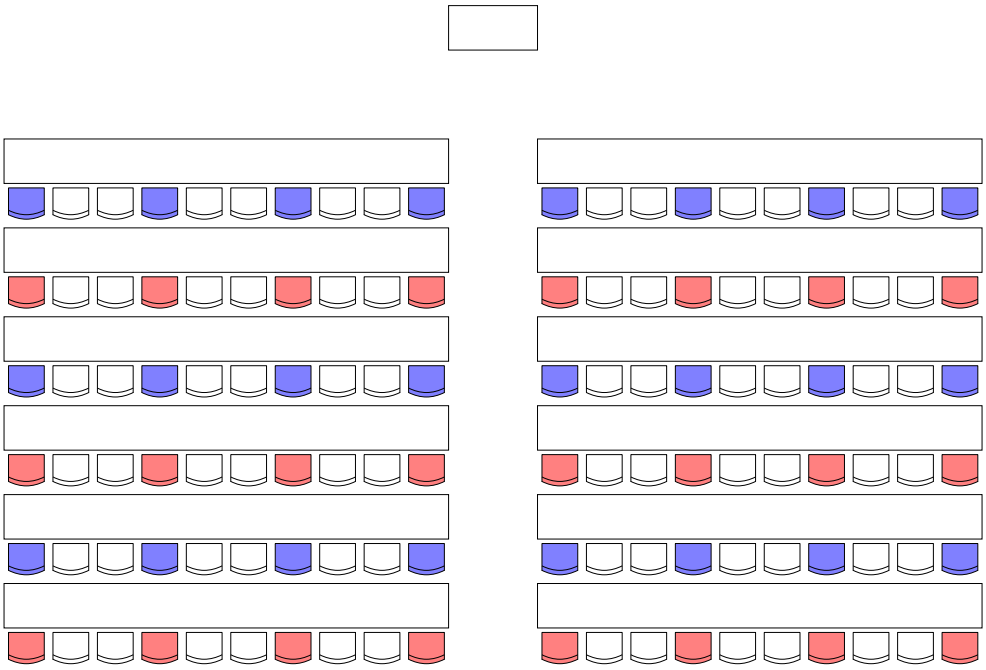

Figure 3.2: Example seating of examinees in a 120-seat lecture hall – two exams with 24 examinees each

3.2 Solutions with ad-hoc infrastructure

Sketch of how a typical handball-court hall can be furnished for exams to make space for 210 students.

Included are sketches of seating, power distribution, fixed network distribution, and placing of any wireless base stations.

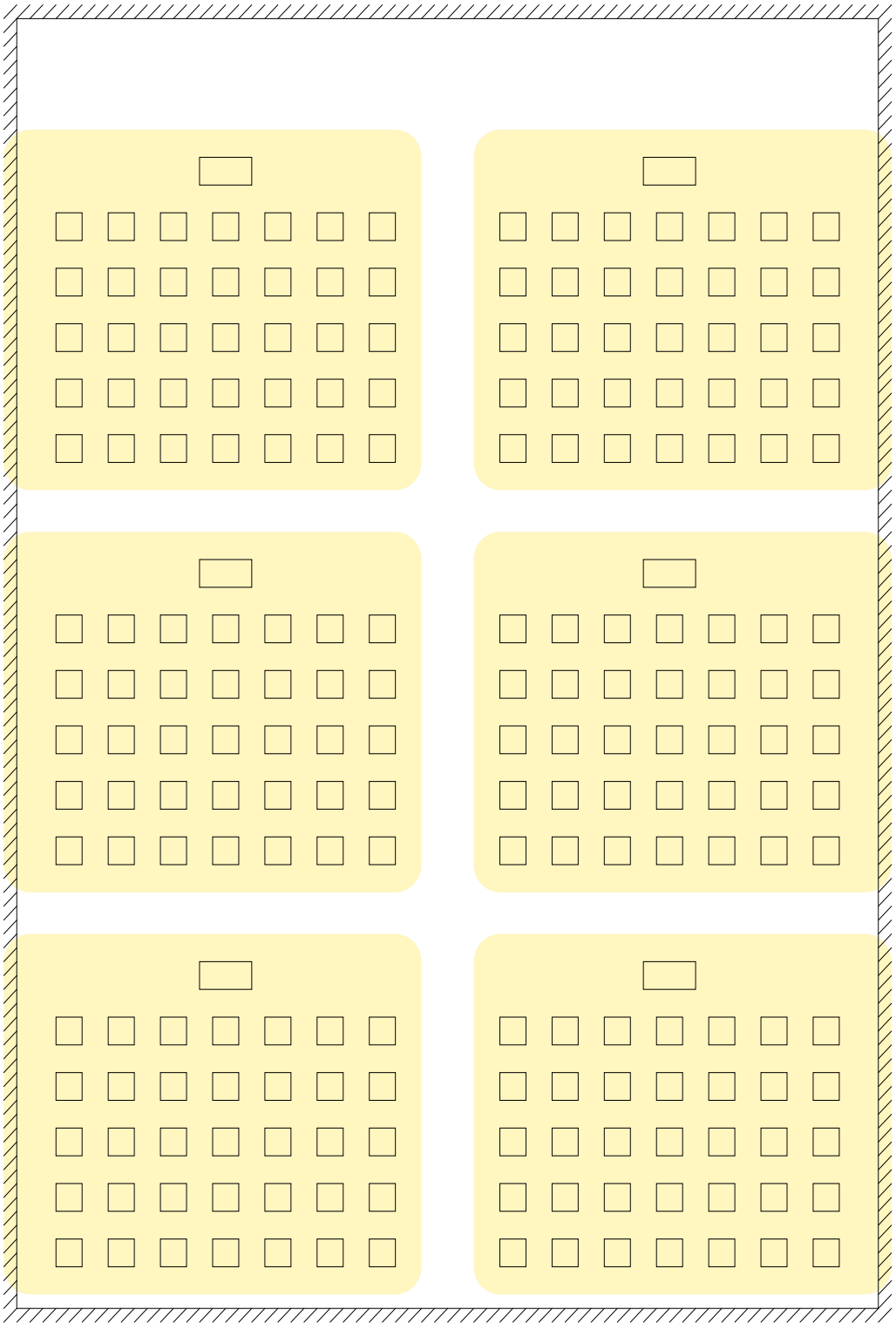

Figure 3.3: Proposed seating of students in a handball hall (24 by 48 metres), adopted from UiA

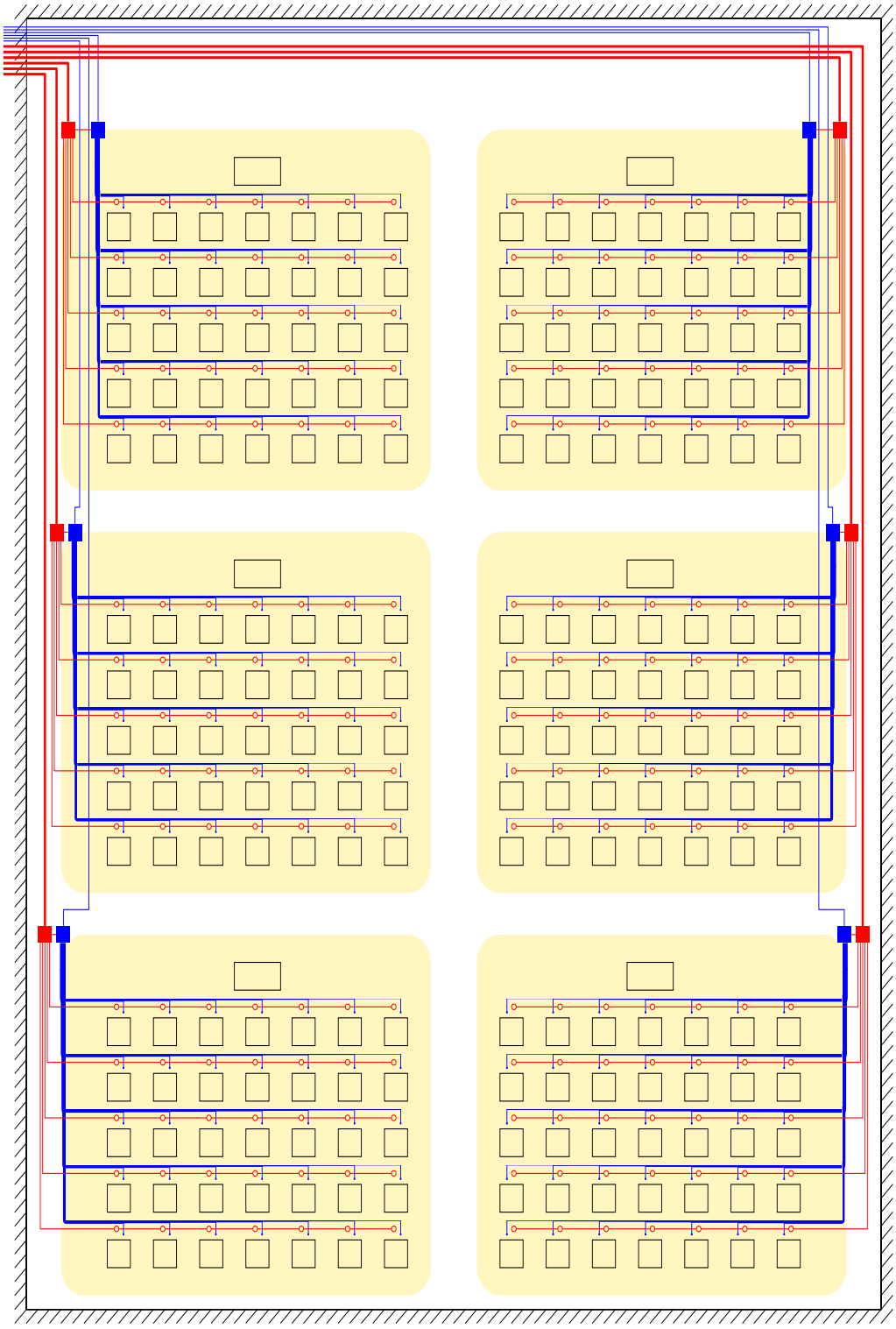

Figure 3.4: Proposed distribution of power and network in a handball hall (24 by 48 metres)

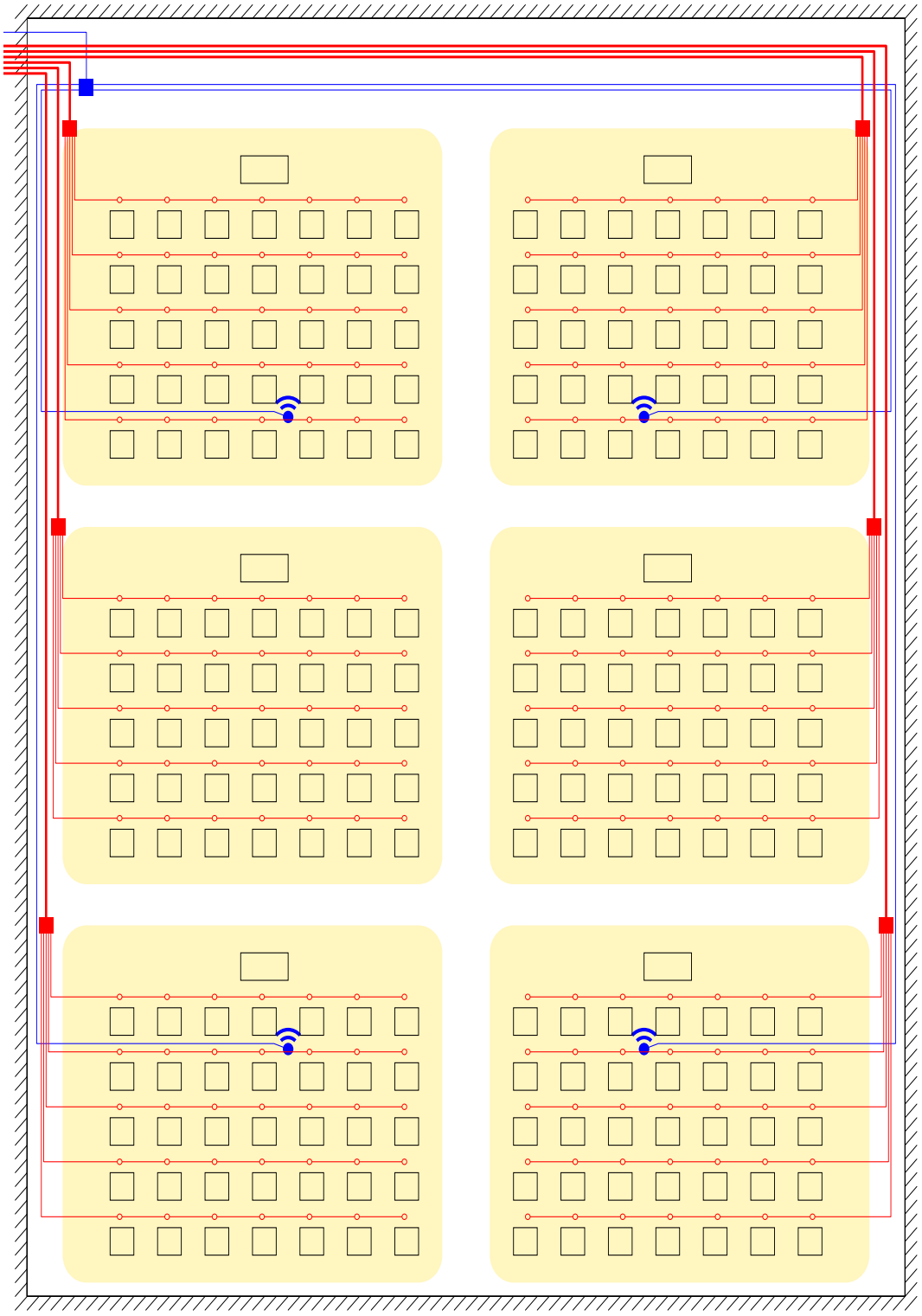

Figure 3.5: Proposed power distribution and base station placement in a handball hall (24 by 48 metres)

References

Reference documents of the relevant regulations and guidance documents are freely available for downloading:

[1] The Norwegian Labour Inspection Authority, in its guidance document on climate and air quality in the workplace (“Veiledning om klima og luftkvalitet på arbeidsplassen”) http://www.arbeidstilsynet.no/artikkel.html?tid=78883)

[2] Lyskultur HMS og riktig lys på arbeidsplassen (“Safety and proper lighting in the workplace”) http://www.naaf.no/Documents/Friskjobb.no/Arbeidsmilj%C3%B8/HMSkursLys.pdf

[3] Guide to the Regulation concerning workplaces and work premises http://www.arbeidstilsynet.no/artikkel.html?tid=78647.

[4] The Norwegian Labour Inspection Authority, in its guidance document on climate and air quality in the workplace (“Veiledning om klima og luftkvalitet på arbeidsplassen”, http://www.arbeidstilsynet.no/artikkel.html?tid=78883

Also see references to other supporting documentation in the separate sections.

UFS 102: Requirements for Generic Cabling Systems

UFS 112: Recommended Security Systems for Wireless Networks

UFS 122: Recommended ICT Security Architecture in the Higher Education Sector

UFS 127: Guide to configuring eduroam using a Cisco wireless controller

Glossary

BPD	Best Practice Documentation
BYOA	Bring Your Own Application
BYOD	Bring Your Own Device
CBP	Campus Best Practice
DNS	Domain Name Server
Gbit	Gigabit (10^9 bits)
HSE	Health and Safety Executive
Mbit	Megabit (10^6 bits)
UiA	Universitetet i Agder (University of Agder, Norway)
VDI	Virtual Desktop Infrastructure
WPA2/PSK	Wi-Fi Protected Access 2 – Pre-Shared Key (also known as WPA or WPA2 Personal)