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Physical Infrastructure for Digital Assessments

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Abstract

This document provides recommendations for physical infrastructure in permanent and temporary premises used for digital assessments. All standards for physical cabling of computer networks are described in GN3-NA3-T4-UFS102, and recommendations for wireless networks are described in GN3-NA3-T4-UFS112 and GN3-NA3-T4-UFS127; these will not be dealt with in the present document. The present document forms part of a series of documents recommending solutions for hosting digital assessments.

Document Revision History

Version	Date	Chapters	Change	Responsibility	Approved
0.1	27.06.2014	All	First version of BPD sent to the project group	MS	
0.2	26.07.2014	All	Structural fixes		
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Part I: Introduction

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

Best practice documents (BDPs) have been developed to describe recommended solutions for digital assessments 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 assessments, 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 assessments. 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 discuss existing software solutions for digital assessments. The documents focus on infrastructure requirements, whereas requirements concerning software, servers, virtualisation solutions, firewalls, and surveillance systems follow from the chosen software solution.

1 Document Structure

- **UFS 145: Physical Infrastructure for Digital Assessments**

  Contains recommendation for physical infrastructure in permanent and temporary halls used for holding digital assessments.

Other BPDs in the series on digital assessments:

- **UFS 146: Clients for Digital Assessments**

  Contains recommendations for clients used for digital assessments.

- **UFS 147: Integrating Solutions for Digital Assessments**

  Contains recommendations for datasets and formats for data exchange between solutions for digital assessments.

2 Workflow for Hosting Digital Assessments

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

1. Get an overview of the planned use of digital assessments in the coming assessment period
2. Get an overview of the demands that the planned assessment and chosen assessment 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 assessments 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 assessments 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 take into considerations questions concerning the procurement process itself, such as administrative and contractual provisions, the contracting process, tender evaluation, or operating and service agreements.

3 Changes in this Revision

This is the first version of this BPD.

Part II: Fundamentals

Part III offers some examples of infrastructure solutions for digital assessments, 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 assessments. 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 assessments.

It is very important to describe the demands made on infrastructure by a chosen assessment solution and software at an early date. It is also important to clarify as soon as possible whether the digital assessments 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, or similar.

4 Digital Classroom Assessments, with and without Notes

The focus of this BPD is on digital assessments that replace the traditional pen-and-paper-based written in-class assessment. It covers written assessments with and without notes and books.

5 Delimiting the Topic

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

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

Infrastructure solutions to support oral assessments or take-home assessments 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 forms of assessment than written digital in-class assessments with proctors pre-sent in the room.

6 Physical Requirements

6.1 Space

There is no (Norwegian) national standard governing the allotment of space per candidate in the assessment room. The local assessment offices at different institutions relate to local rules. Typical figures range from 3.5 to 5 m2 per candidate seat, depending somewhat on the size and shape of the room. Digital assessments pose new visual privacy problems, and hence require greater distance between candidates taking the same test. It may be practical to mix the candidates according to a set pattern so that no two candidates sit beside each other or behind each other in the same row.

6.2 Power

Power consumption differs between the different types of client. In the planning phase, one must take into account that the assessment room may be used with all kinds of client. When desktop PCs are used as clients, each candidate 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	200 W	10	15
Laptop PC	100 W	20	30
VDI client	50 W	40	60
Tablet	15 W	100	150

Table 6.1: Indicative power consumption by client type

6.3 Cooling

When laptop PCs are used as clients, we may expect each client to supply as much heat as the number of people in the assessment room. Typically, one must assume 100W of power consumption per candidate. This may seem excessive for modern equipment, but one has to take into ac-count the additional power going to charge the computer battery. In an average-sized room with 100 candidates, this may mean up to 10KWA of additional heat. This may trigger additional ventilation and cooling requirements, or require the number of candidates 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, http://www.arbeidstilsynet.no/artikkel.html?tid=78883) sets out the following standards for work-place 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.*

6.4 Air

A digital assessment 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 Norwegian Labour Inspection Authority’s “Guidance on climate and air quality in the workplace” (http://www.arbeidstilsynet.no/artikkel.html?tid=78883) 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 deter-mined as the sum of the following:*
>
> *Human air needs: 7.0 l/s per person*
> *Airing of materials 7 - 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.

Drafts
Drafts 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 draft. 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 CO2 content is due to inadequate ventilation given the number of people in the rooms. Satisfactory ventilation results in concentrations below the 1000 ppm standard.

6.5 Lighting

The Norwegian group "Lyskultur" have published a recommendation "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 (http://www.naaf.no/Documents/Friskjobb.no/Arbeidsmilj%C3%B8/HMSkursLys.pdf).

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 6.2: Lighting systems

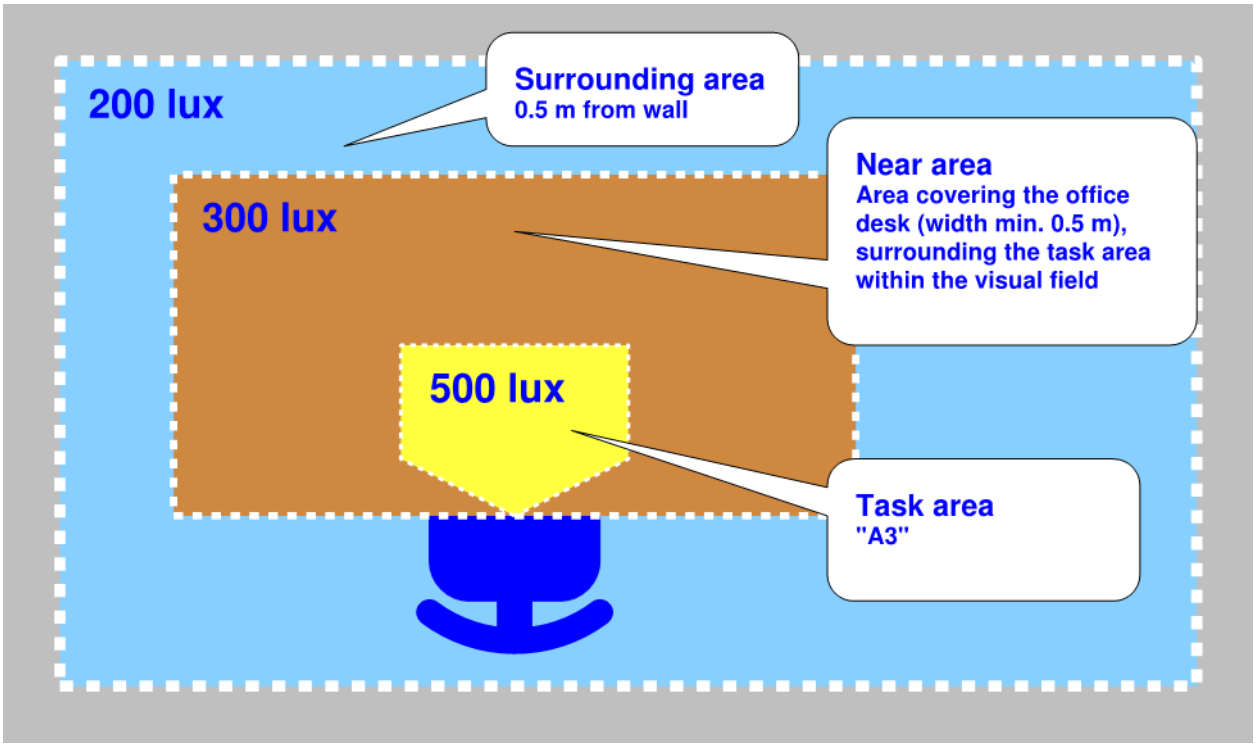

Figure 6.1: Lyskultur's definition of lighting needs in the workplace.

6.6 Bandwidth

When calculating bandwidth needs for the assessment hall, it is very helpful if the digital-assessment solution providers supply figures for bandwidth need per assessment candidate. The contents of the assessment 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 candidates start their assessments, and in the finishing phase. During the assessment, 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 assessment	1Gbit	50	250
Desktop PC (wired), closed assessment	1Gbit	100	500
Laptop PC (wired), open assessment	1Gbit	50	250
Laptop PC (wired),	1Gbit	1000	500

Client type	Typical client connection capacity	Number of clients per 100Mbit uplink	Number of clients per 1Gbit uplink
closed assessment			
Laptop PC (wireless), open assessment	802.11ac up to 866Mbit	50 per base, 2 bases minimum	250
Laptop PC (wireless), closed assessment	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 6.3: Figures for budgeting bandwidth (uplink)

6.7 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 are-as/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 assessment hall.

7 Universal Design (Adaptive Solutions)

For digital assessments, 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 Norwegian 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 tools and assessments, 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 Norwegian 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 assessments, 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 assessment 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 assessment 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 assessment 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 candidate in the assessment 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 work station) must total at least 2.3 metres. In a permanent assessment hall, at least 5% of the desks should have adjustable height (up to a standing position). Where this is not possible, an alternative assessment 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 assessment hall.

Permanent Infrastructure

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

To make the most efficient use of the halls, digital assessments should make as little demand as possible on infrastructure changes between assessments. This means that assessments 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 assessment 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.
- Assessments are easily planned, as the room is only used for assessments.
- 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 assessments.
- Cheating is harder; we control the equipment.

Disadvantages

- The room is dedicated to assessments, 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.

7.1 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 assessments.

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

8 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 assessment equipment, which ties up capital, and cannot realistically be scaled up to cover the need for computers for digital assessments

9 Infrastructure for BYOD (Laptop Computer)

For assessments where one wishes to use BYOD equipment, it is important that the assessment has a form that requires only minimal installed software: ideally speaking, just a wireless network (cf. GN3-NA3-T4-UFS112) and a working browser. It is preferable for the assessment to be limited to use of a "LockDown Browser," or to solutions employing VDI, which only require a simple client to be installed.

9.1 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 digital assessments.
- 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 assessment has been held without problems.

10 VDI Infrastructure

In a VDI infrastructure, the assessment halls will be equipped with “dumb” terminals (screens, key-boards 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 assessment sup-port 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 assessment equipment, which ties up capital, and cannot realistically be scaled up to cover the need for computers for digital assessments

11 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 assessments (gymnasiums, sports halls, and similar).

11.1 On-campus Halls

Most institutions have a number of halls that can be used for digital assessments. The common de-nominator is that these halls are not equipped with permanent infrastructure for digital assessments, 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 assessments
- Presupposes that the rooms are furnished with tables and chairs
- The room must be rigged for power, perhaps temporarily for assessment purposes
- Presupposes that a wireless network has been permanently set up and has sufficient capacity.

Advantages

- The assessment 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 assessments.
- Scheduling can be demanding if the room is used both for assessments and teaching
- Difficult to take sufficient account of ergonomics
- Holding a BYOD assessment requires extra hardware and personnel resources

11.2 Large Halls, Gymnasiums

Digital assessments may be held in large halls or gymnasiums that are rigged for digital assessments. 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 candidate 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 assessments.

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

11.3 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 assessments. 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 assessments. If the lecture hall has 200 seats, one could seat anywhere from 40 to 50 candidates in the hall.

12 Need for Spare Equipment

There will be a need for spare equipment during assessments, but the extent of the need is un-known, 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%

12.1 Training Needs

- Hold workshops in advance
- For BYOD-based assessments, 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 assessment halls takes a good deal of work.

12.2 Competence at Using the Solution

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

12.3 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 assessment. 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.

12.4 Fallback Solutions (Redundancy)

The need for fallback solutions in connection with digital assessments is bigger and more extensive than for written in-class assessments. 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 candidate seats
- Network connection for the building and the assessment hall
- Network for the assessment hall, fixed vs. wireless
- Spare hardware for assessments
- eduroam vs. simpler net access
- Feide vs. alternative authentication
- DNS
- Digital assessment solution (electronic vs. paper)
- Solutions for handing in work (printouts, memory sticks, and similar.)

12.5 Maintenance Window (Maintenance Day)

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

It will be necessary for the institution to define a regular maintenance window (day) in agreement with the infrastructure provider and the assessment-solution provider. If several solution providers for digital assessments 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 assessment solutions.

13 Security

13.1 Wireless network security

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

13.2 Risk and Vulnerability Assessment

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

13.3 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 assessments 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 candidates from several assessments in the same hall, so that neighbours do not take the same assessment. It is also possible to seat candidates further apart than one usually does in paper-based assessments.

Part III: Examples of Infrastructure for Digital Assessments

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

14 Solutions with Permanent Infrastructure

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

14.1 Seminar Rooms, Classrooms

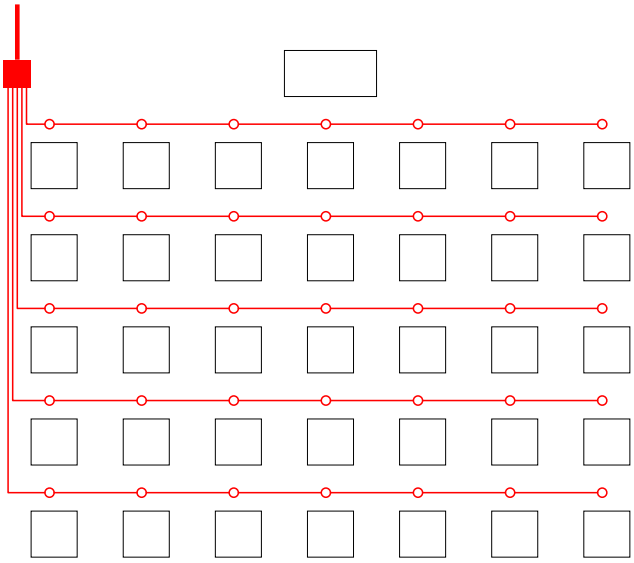

Figure 14.1: Sketch of a solution for power distribution in small seminar rooms and classrooms.

14.2 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 assessments, e.g. two-hour assessments.

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 assessments.

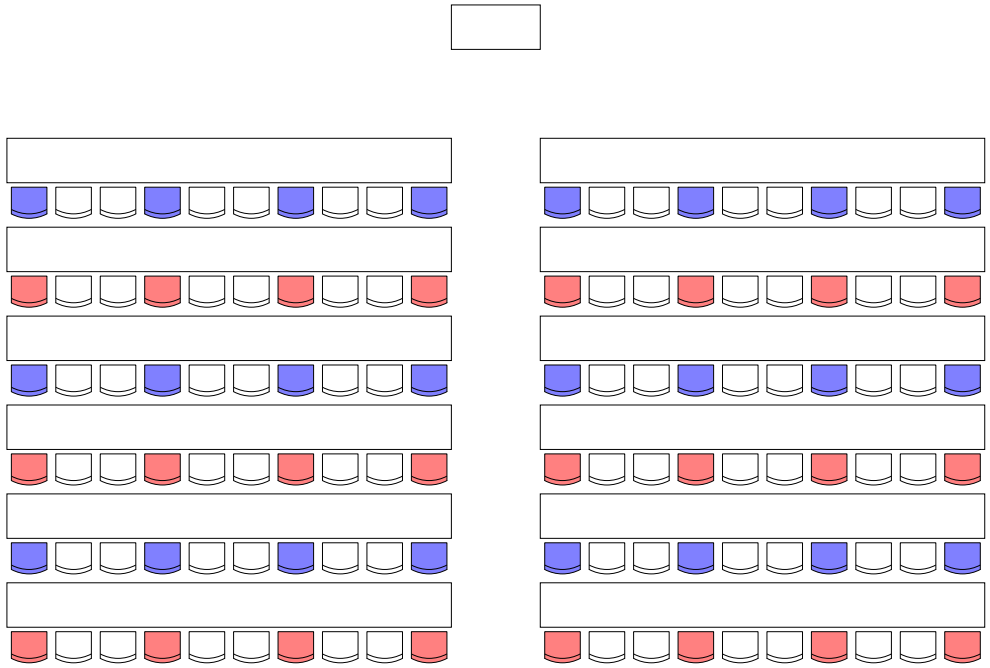

Figure 14.2: Example seating of candidates in a 120-seat lecture hall

Two assessments with 24 candidates each.

15 Solutions with Ad-hoc Infrastructure

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

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

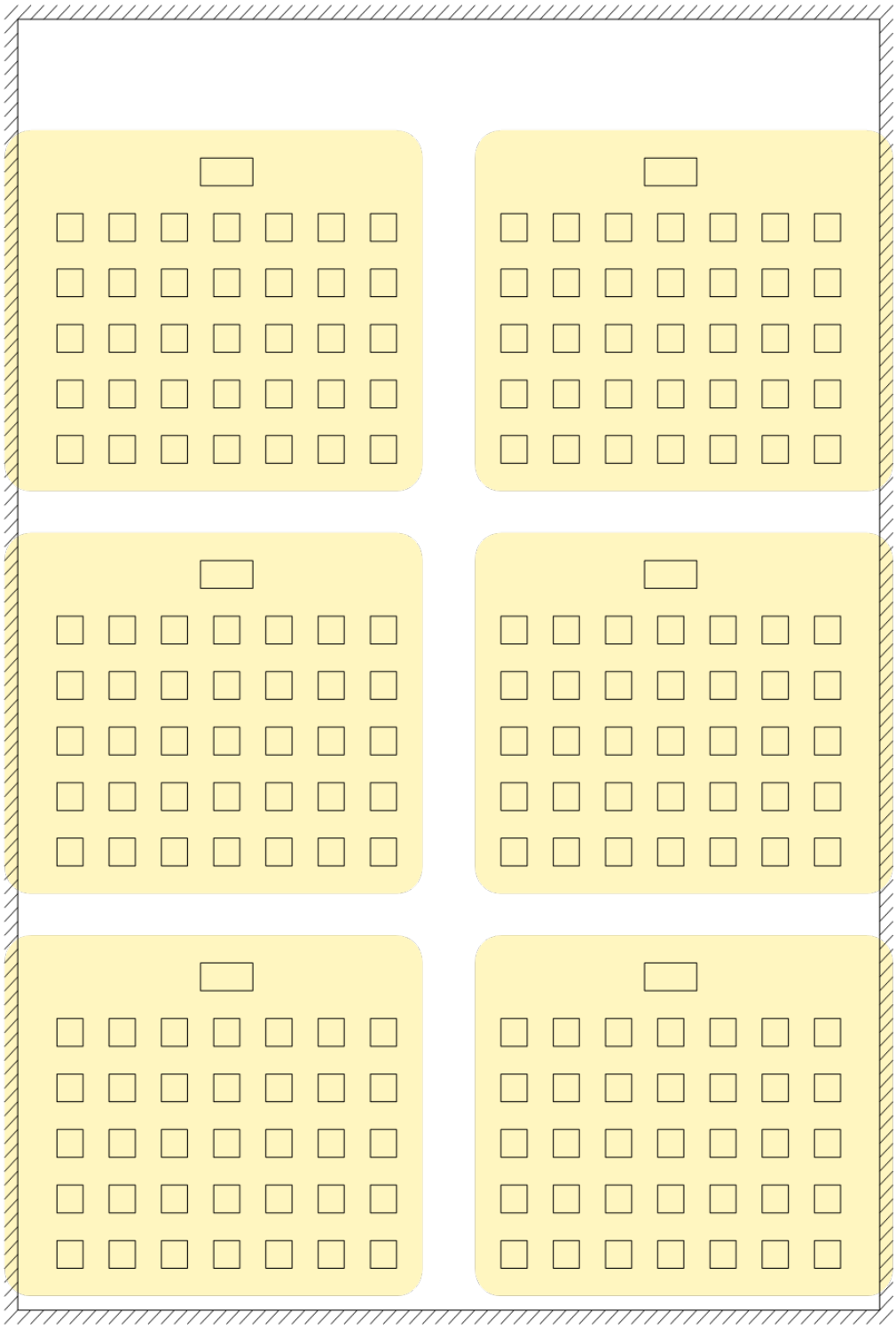

Figure 15.1: Proposed seating of students in a handball hall (24 by 48 metres), adopted from UiA

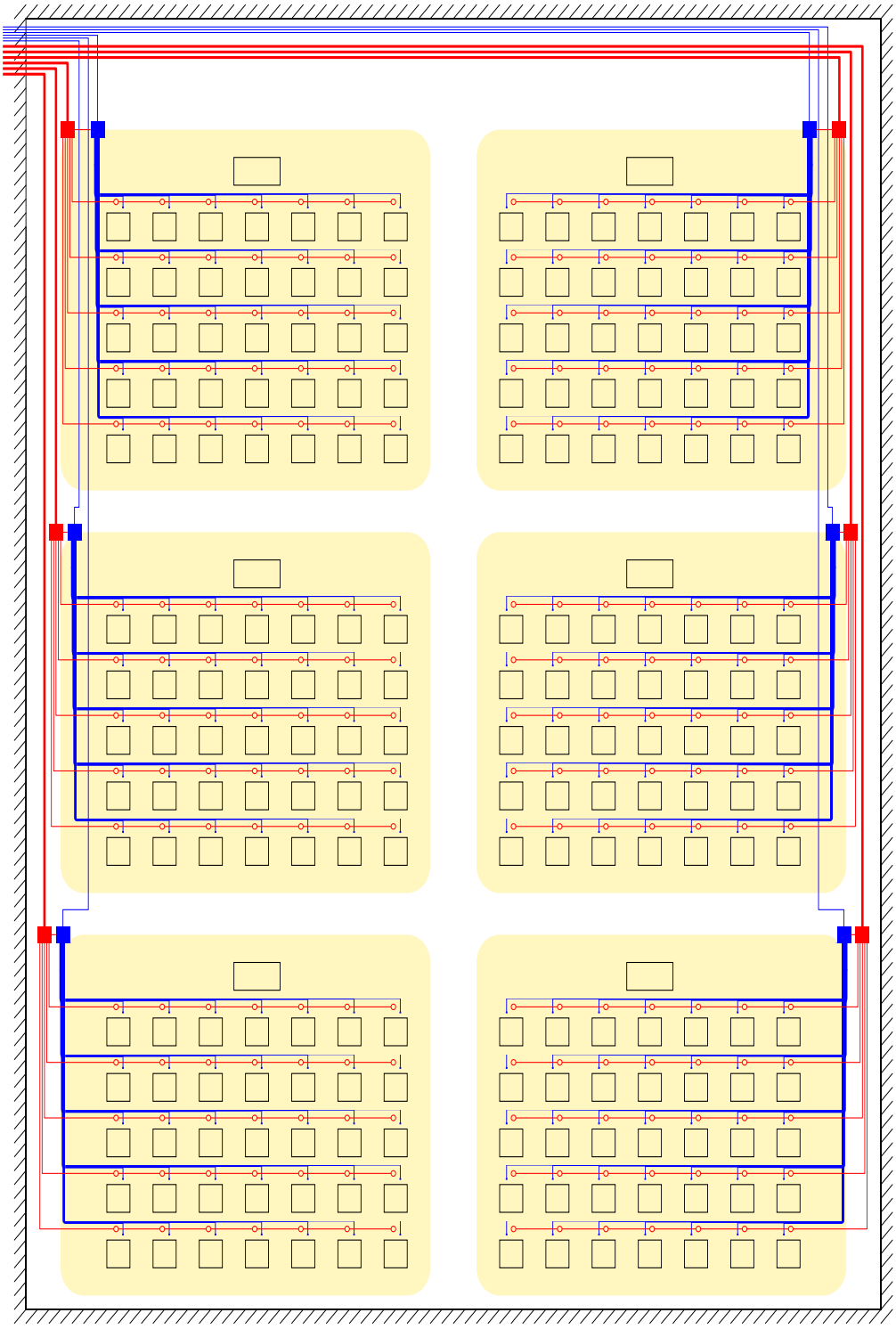

Figure 15.2: Proposed distribution of power and network in a handball hall (24 by 48 metres)

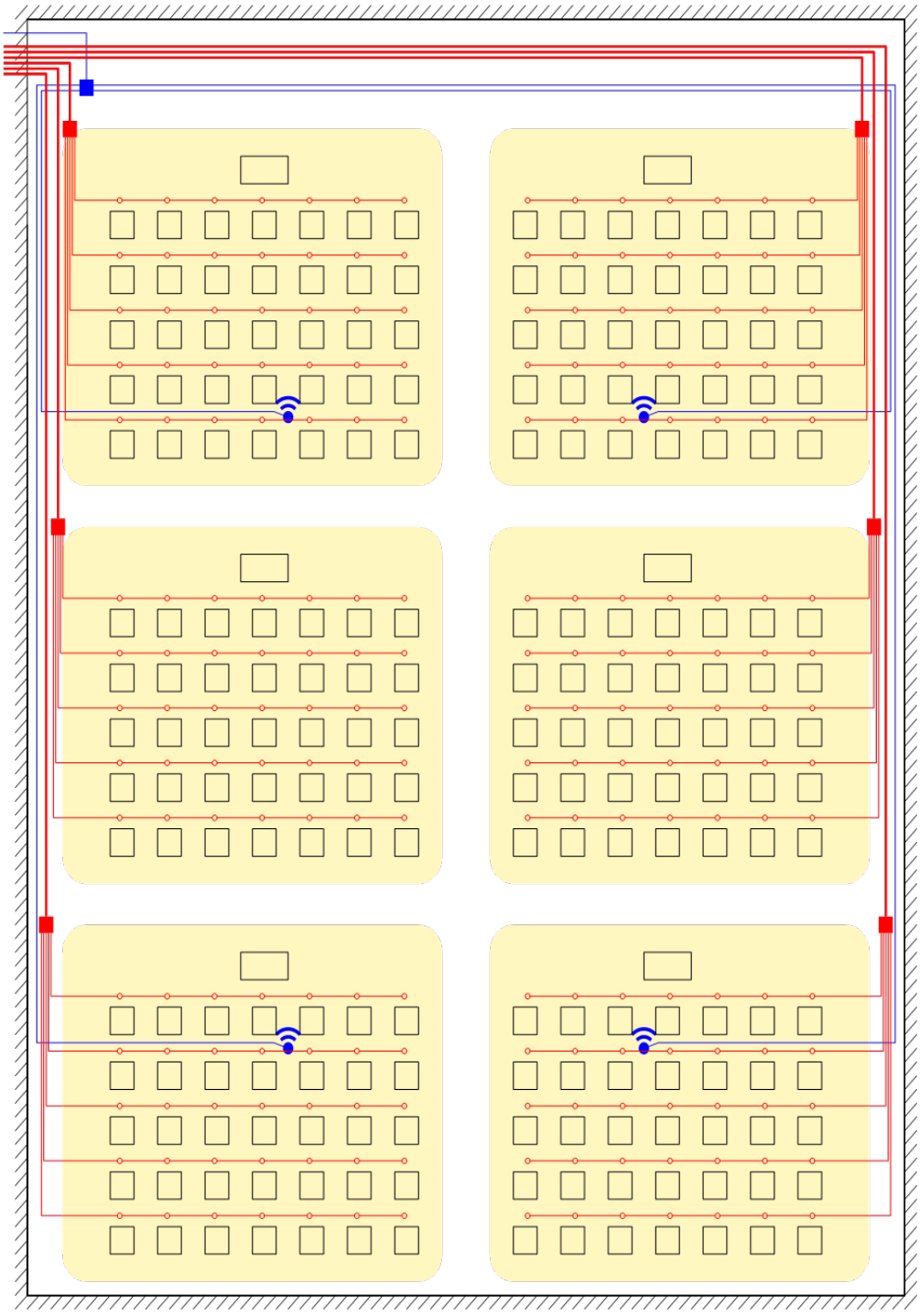

Figure 15.3: Proposed power distribution and base station placement in a handball hall (24 by 48 metres)

References

References to relevant regulations and guidance documents freely available for download:

[1] The Norwegian Labour Inspection Authority's guidance document on climate and air quality in the workplace, URL: http://www.arbeidstilsynet.no/binfil/download.php?tid=29437.

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

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

GN3-NA3-T4-UFS102: Requirements for Generic Cabling Systems,

URL: https://www.terena.org/activities/campus-bp/pdf/gn3-na3-t4-ufs102.pdf

GN3-NA3-T4-UFS112: Recommended Security Systems for Wireless Networks,

URL: https://www.terena.org/activities/campus-bp/pdf/gn3-na3-t4-ufs112.pdf

GN3-NA3-T4-UFS122: Recommended ICT Security Architecture in the Higher Education Sector,

URL: https://www.terena.org/activities/campus-bp/pdf/gn3-na3-t4-ufs122.pdf

GN3-NA4-T4-UFS127: Guide to configuring eduroam using a Cisco wireless controller,

URL: https://www.terena.org/activities/campus-bp/pdf/gn3-na3-t4-ufs127.pdf