Visual Health Record (VHR) and the uVis Tool

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Problems with Electronic Healthcare Records

Traditional EHR systems have some problems. They show only one kind of data on each screen, either notes, lab results, diagnostic imaging, or medication. It is difficult for the clinician to keep all the data in mind and to know if there is more (Meyer 2010). This makes it hard to get a good overview of the patient's total situation. Most data is shown as text and digits, which requires a cognitive effort to perceive. This causes errors and decreases clinicians' performance (Ahmed 2011). Different medical specialties need to record and see different data because they perform different tasks. In addition, all kinds of clinical work share a common set of core data. With time, some data loose their relevance and new needs arise. This is important for most medical specialties. These shortcomings sometimes endanger patients' lives.

Existing visualization tools either require professional programming skills or can only create simple, predefined visualizations like pie charts. The IT suppliers can make data visualizations and change their systems, but this takes time and is expensive. And quite often the result does not match the expectations.

In this paper we show a Visual Health Record (VHR) that

- has all clinical data in one graphical screen
- can use any relational database
- can be changed and extended locally

The VHR is based on a visualization tool (uVis) that allows non-programmers

- to build non-standard data visualizations
- use and update databases without heavy SQL
- interact with end-users through event handlers

The first outline of the VHR and uVis dates back to early 2009. The systems have been under development since then.

References:

1. Ahmed, Adil MBBS et al. The effect of two different electronic health record user interfaces on intensive care provider task load, errors of cognition, and performance. Critical Care Medicine: July 2011 - Volume 39 - Issue 7 - pp 1626-1634. doi: 10.1097/CCM.0b013e31821858a0

2. Meyer R et al. Interoperability in hospital information systems: return-of-investment. Swiss Medical Informatics Proceedings 2010

Patient List

When you open the Visual Health Record system (VHR), it shows the department's patient list.

The button *New Patient* opens a form for registering a patient and entering demographic data. The button *Medicine Intakes* shows a form with all the patients of one ward or nursing care group, their current medications, and on a time line when they have got medicine and their next planned dose.

In the Patient List view, a click on the *Patient Record* button shows the Visual Overview of a single patient. The patient's *Clinical Observation* button opens a form with the vital signs and more, depending on the department's preferences. In this form new data can be entered.

Visual Overview

All data about a single patient is shown in this window.

Time scale: The top panel of the Visual Overview shows a time scale. All the patient's events and healthcare activities (e.g. investigations and treatments) are placed according to this scale. It shows time from the patient's birth till some time into the future. So this view will also show planned activities. You can scroll and zoom the sections of the time scale.

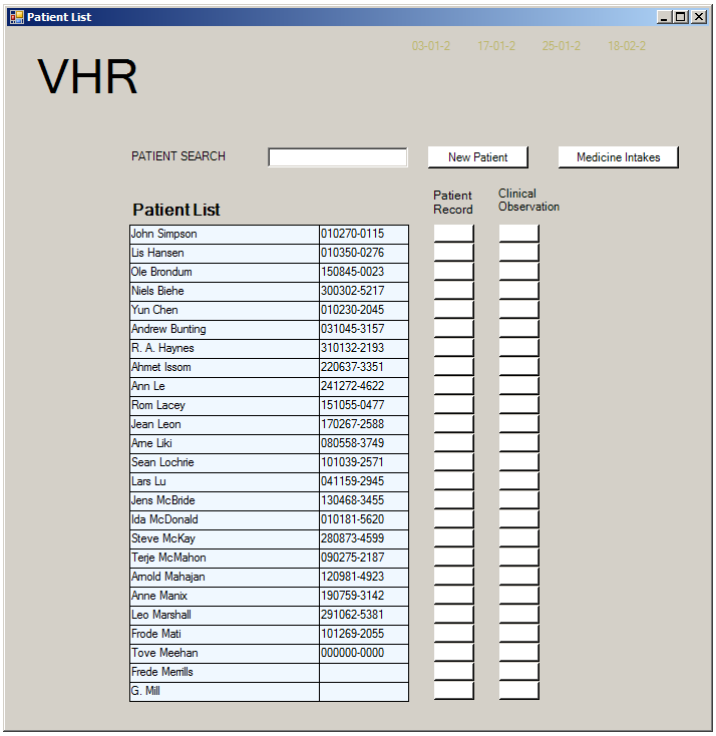
Notes: Notes (clinical notes, progress notes) are written by the clinicians as free text. Each note is marked as a triangle. This department has separated them into a row with nurses' notes and a row with physicians' notes.

Diagnoses: The panel below the note panel shows the patient's diagnoses, each marked as a bar. You can see the start and end time of each diagnosis.

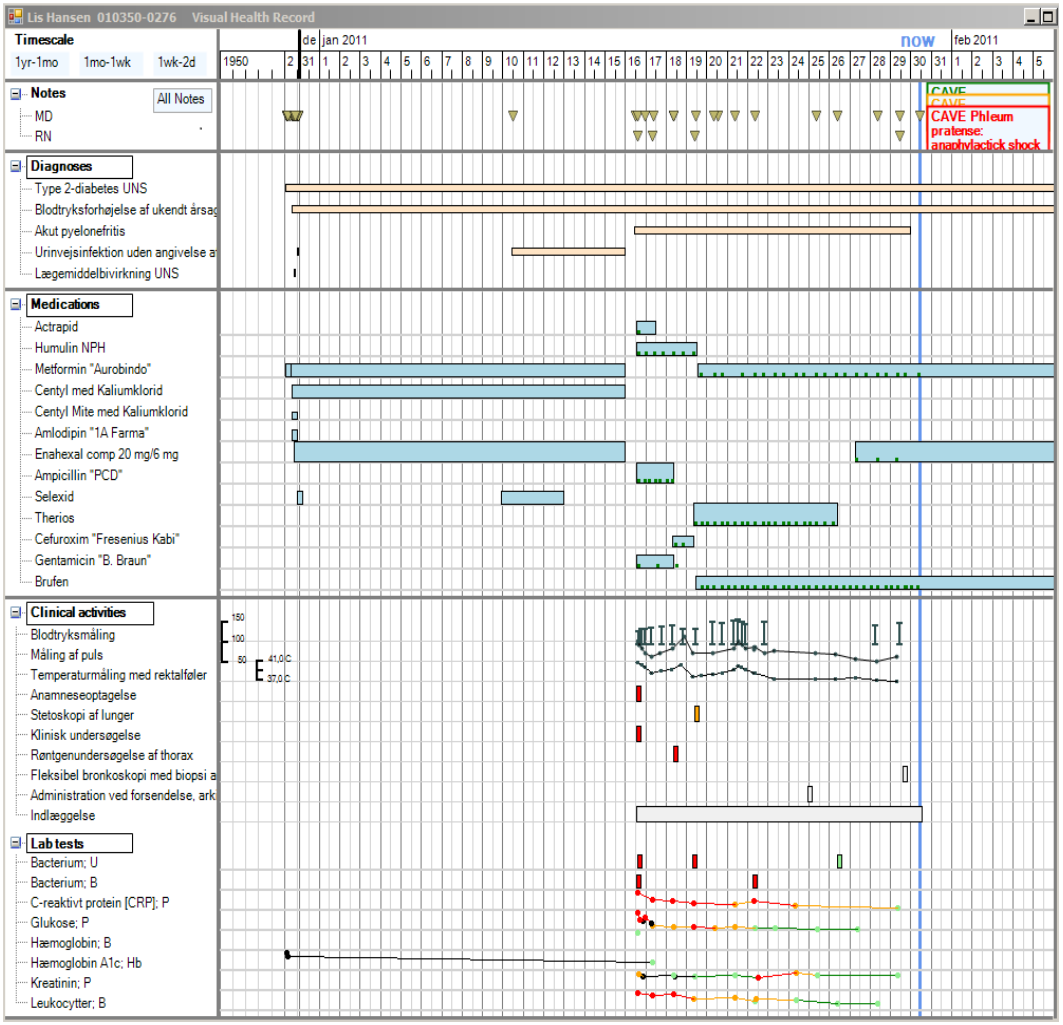
Medications: The next panel shows the patient's medication list ordered as in the international Anatomical Therapeutic Classification (ATC) of medicines. Each medicine order is shown as a bar and the height of the bar indicates the dose relative to its Defined Daily Dose (DDD).

Clinical activities & lab tests: The last panel consists of two parts. The first part comprises clinical observations, investigations, and various procedures, collectively called clinical activities. The second part shows the patient's biochemistry and microbiology tests, called lab tests. Activities and tests with a numerical result are shown as simple graphs. When you click the label to the left, the graph will expand.

Patient List



Visual Overview



Seeing Details in the Visual Overview

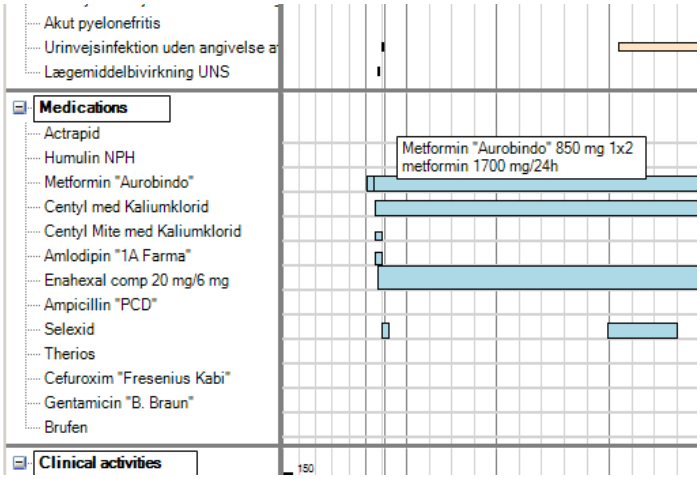
When you place the cursor on a graphical element (triangle, bar, or graph point), the system shows details in a box adjacent to the element, e.g. the full text of a note, details of a medication order, or the value of a graph point. When you click the element, you get a form with more details. Different kinds of elements may have different forms, e.g. an x-ray picture or an anatomical map. We show examples below.

Notes

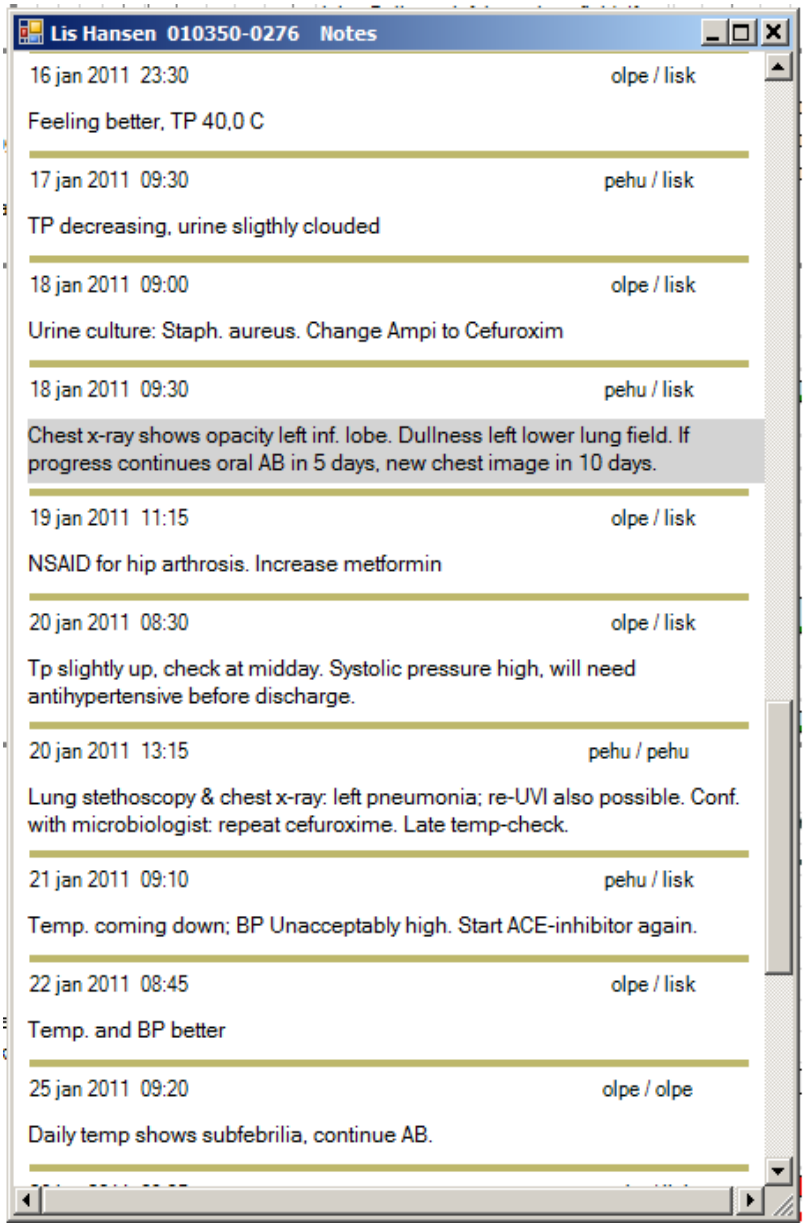
You can read a note text by placing the cursor on a note marker. A click on the triangular marker of a note opens a window that shows a section of the notes in chronological order with the chosen note highlighted. You can browse or read all the notes by scrolling, or you can choose the notes from a certain kind of clinician, e.g. notes by physicians. Clicking on ”All Notes” shows notes from all kinds of clinicians.

The first line of a note shows the date and time, user name of the clinician responsible for the contents of the note and the user name of the user actually entering the note text into the system. The department can set it up differently, e.g. with full names shown.

Details



Notes



Diagnoses

The diagnosis names in the left side of the diagnosis panel are ordered according to the underlying classification system. Each diagnosis has its own line with a bar representing the diagnosis. The ends of the bar mark the start and end time for the particular diagnosis.

When the cursor hovers over a diagnosis bar, an explanatory pop-up box shows the name of the diagnosis, the user name of the clinician who made the diagnosis, and the time interval where the diagnosis is valid.

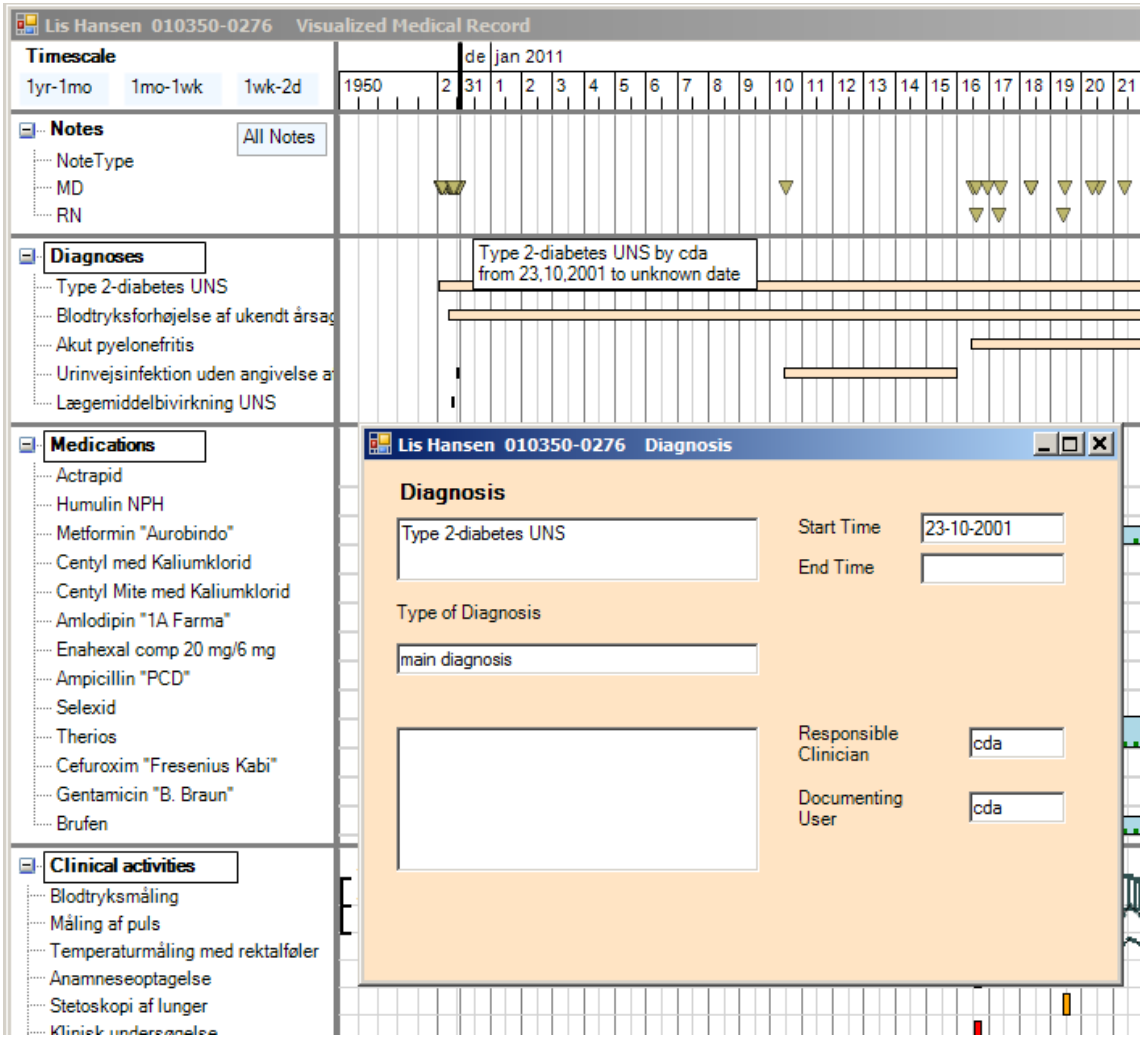
A click on the diagnosis bar gives a window showing all the details about this diagnosis. Top left in this window is the name of the diagnosis and right below is a field stating which type or kind of diagnosis this is, e.g. main diagnosis, action diagnosis, or supplementary diagnosis. The empty field below is the space for an associated note. In the right side of the window are the start and end time (if any), the clinician responsible for making the diagnosis, and the user who entered this data.

A new diagnosis is recorded in the same window, but the fields are empty at the start. The empty window opens by clicking the frame ”Diagnoses” in the left side of the Visual Overview. This opens the classification system. By clicking subcategories you can reach any diagnosis in the system and record it with a final click.

The system can use any set of classifications, e.g. SNOMED-CT. From a short drop-down list a diagnosis type can be selected, e.g. ”referral diagnosis”, ”main diagnosis”, or ”supplementary diagnosis”. A note can be associated with the diagnosis if it is written in the *Note* field below the type of diagnosis.

For a new diagnosis, default start time is current time, but the clinician can change this to any time in the past. If necessary, the responsible clinician and the documenting user can be recorded independently, e.g. when a dictation device is used.

Diagnoses


Lis Hansen 010350-0276 Visualized Medical Record
Timescale
1yr-1mo
1mo-1wk
1wk-2d
de jan 2011
1950
Notes
All Notes
NoteType
MD
RN
Diagnoses
Type 2-diabetes UNS
Blodtryksforhøjelse af ukendt årsag
Akut pyelonefritis
Urinvejsinfektion uden angivelse af
Lægemiddelbivirkning UNS
Type 2-diabetes UNS by cda
from 23,10,2001 to unknown date
Medications
Actrapid
Humulin NPH
Metformin "Aurobindo"
Centyl med Kaliumklorid
Centyl Mite med Kaliumklorid
Amlodipin "1A Farma"
Enahexal comp 20 mg/6 mg
Ampicillin "PCD"
Selexid
Therios
Cefuroxim "Fresenius Kabi"
Gentamicin "B. Braun"
Brufen
Clinical activities
Blodtryksmåling
Måling af puls
Temperaturmåling med rektalføler
Anamneseoptagelse
Stetoskopi af lunger
Lis Hansen 010350-0276 Diagnosis
Diagnosis
Type 2-diabetes UNS
Start Time
23-10-2001
End Time
Type of Diagnosis
main diagnosis
Responsible Clinician
cda
Documenting User
cda

Medication

The medication panel shows to the left all the patient's medications as their trade names. They are ordered according to the international classification of medicines Anatomical-Therapeutic-Classification (ATC). If the patient gets the same medicine several times, it is shown as different bars on the same line.

Approximate medication doses are shown as the heights of the medication bars. All doses are relative to the Defined Daily Doses. This is an international table of all marketed medications, which can be used to compare medicine prices across suppliers and packages. It is not meant as therapeutic recommendations, although the chosen doses for DDD are realistic. We use the DDDs to show patient's approximate dose per 24h and especially changes in daily dose. This means that dose adjustments appear on the screen as height changes in a bar that shows a continuous treatment. In the database a change of dose and/or dose frequency is recorded as a new medication order. The precise doses are visible in the info box that pops up when the cursor hovers over the medication bar. All details of a medication can be seen in the *Medication Order* window when you click the medication bar. The little green markers in some bars indicate individual intakes of medicine.

In order to record a new medication order, click on the *Medications* label. It opens an empty Medication Order form.

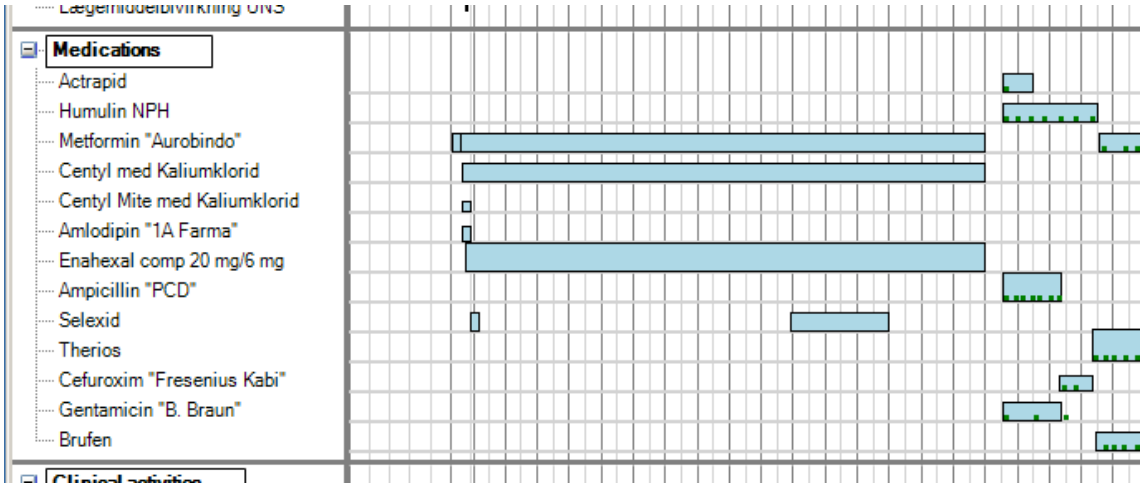
Medicine Intake

Another presentation of patient medication is the Medicine Intake window. It opens with a click on any intake marker in the Visual Overview window or on the button *Medicine Intakes* in the Patient List. The window shows a department's or nursing group's patients together with their current medications. Details about a patient's medications appear on a row (two lines) for each medication.

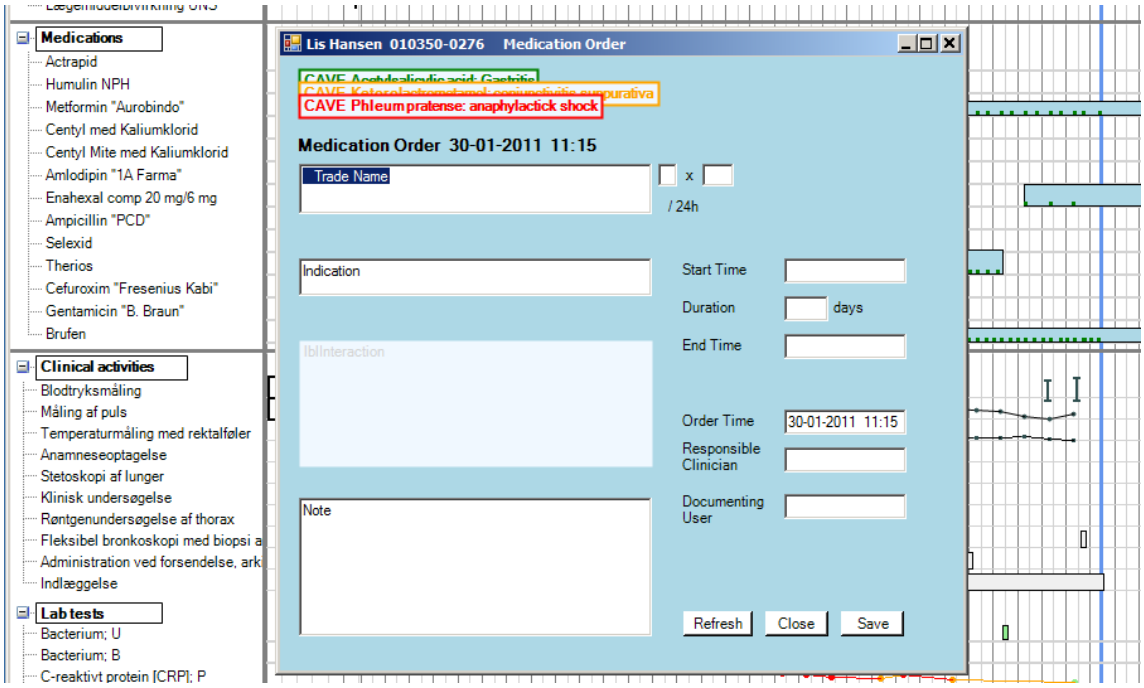
To the right there is a time line with the data about recent (24h) medicine intakes as boxes in green. Further to the right is the next planned dose (white). White intake boxes to the left of the *Now* line show missed intakes.

When the clinician (often the nurse) clicks a white intake box, it changes to green and moves to the *Now* line. At the same time the clinician's user name appears below it. A comment concerning this intake can be written in a field that opens when the green box is clicked. The comment could for instance be the cause of a belated dose or uncertainty about proper ingestion of the medicine.

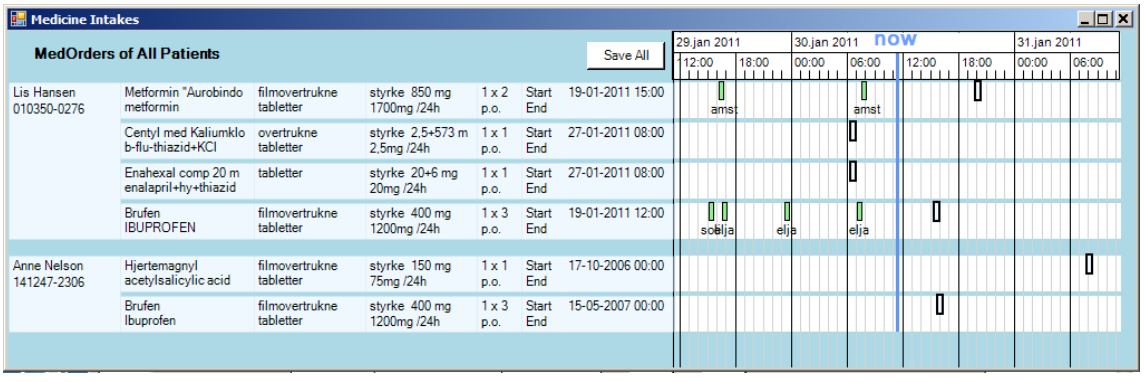
Medications



Medication Order



Medicine Intakes



Clinical Activities & Lab Tests

The lowest panel in the Visual Overview shows markers for investigations and treatments other than medications. In the upper part of the panel the patient's clinical activities are seen. These are healthcare activities other than medications and lab tests. The lower part of the panel shows lab tests.

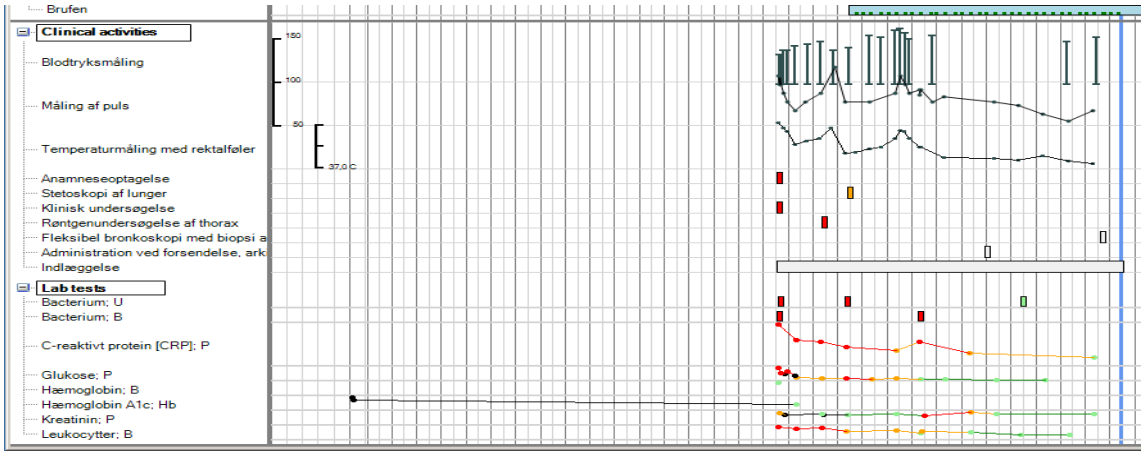
When you order an activity, it shows up as a vertical grey activity box. When the result of the activity has been recorded in the activity order window, hovering the cursor over the grey box or graph point shows the result in the info box. By a click the activity window appears, showing the results when available. If they are not transferred directly from the producing system, they can be entered manually here.

The clinician can sign for the result by marking it as ”normal”, ”uncertain”, or ”abnormal”. The color of the activity box in the Visual Overview then changes to green, yellow, or red, respectively. In this way it can be seen in the overview, not only if a result has been signed for, but also its clinical significance.

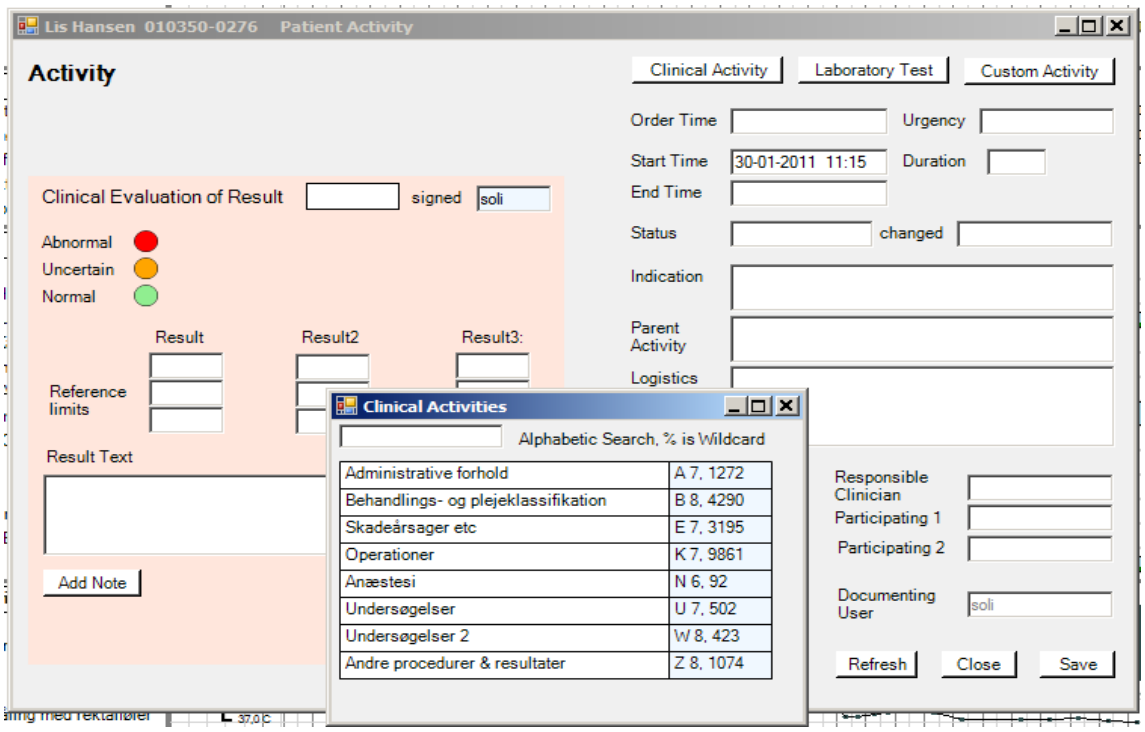
An activity line is expanded or collapsed when you click on the name of that activity. This helps read the numerical results.

To order a new activity the clinician clicks the *Clinical Activities* label. This opens an empty activity window and a list of clinical activity groups. You can click through a hierarchy of groups to select the actual activity to be ordered.

Clinical Activities And LabTests



Activity Window



Special Windows

Some activities use special windows to show results.

Diagnostic Imagery

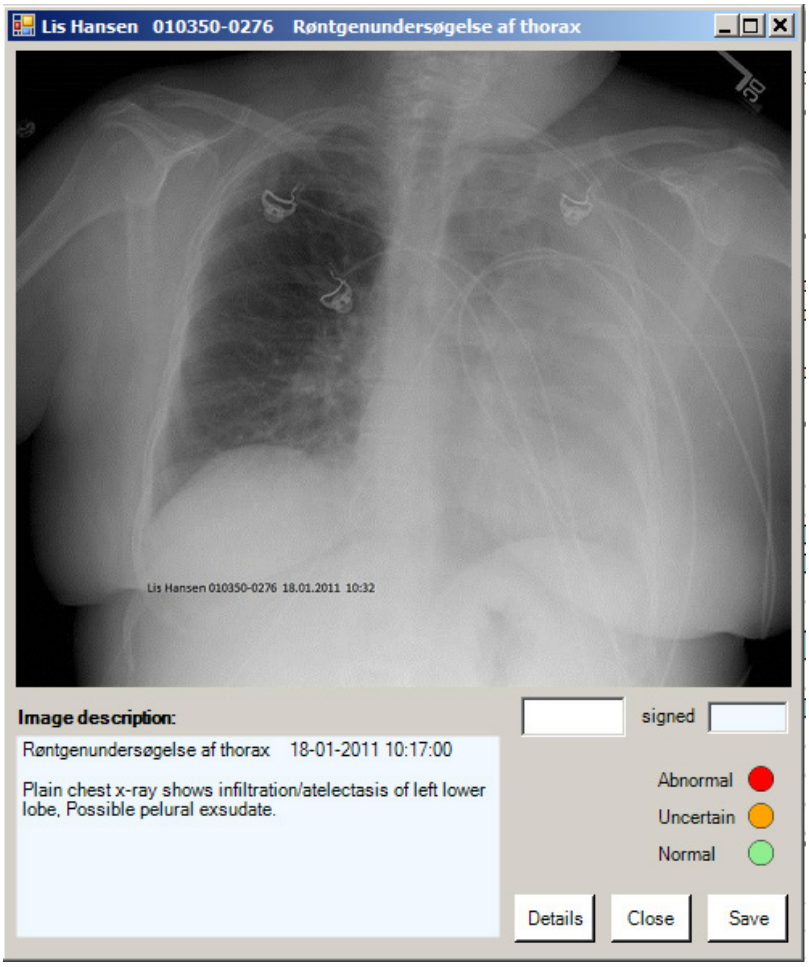
One example is x-ray images. When you click the activity box for an x-ray image, you see the window at the right. The x-ray department has written the description text. You can sign for the activity result by clicking one of the colored circles.

Different medical specialties will of course need different special windows for procedures with spatial or temporal variables, e.g. function tests, physical examinations, and topical treatments. Specialist Medical Associations could participate in the development of such windows, and clinics and departments can create them locally according to their needs.

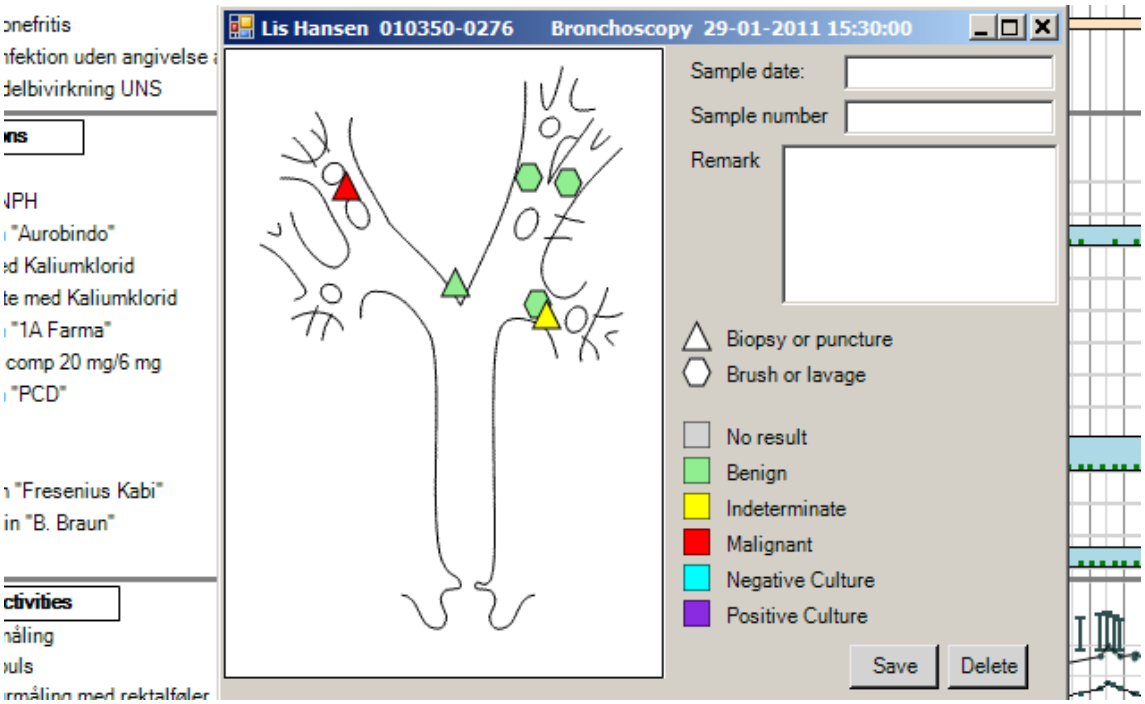
Bronchoscopy

The window on the right shows another example of a special window. A bronchoscopist has marked localizations of samples sent for microscopy or culture. He can place the triangles or hexagons at the time of investigation. If systems are integrated, the results become available in the database, and the bronchoscopy window will automatically show them when it is opened. Otherwise they can be typed in the text boxes and marked with color by means of the colored boxes . A click on a sample marker shows the corresponding details in the text boxes.

Special Window (Diagnostic Imagery)



Special Window (Bronchoscopy)



Changing the system

Every now and then the department's VHR system needs change. Existing windows may be changed or new ones added. This can be done by IT-interested clinicians in the department or clinic ("local designers").

Each window is based on a file. The local designer makes a copy of the existing window files and use a test data base with mockup patient data.

The figure shows how the bronchoscopy window can be changed. The local designer has launched the developer tool, uVisStudio, and started the VHR system through it. All the windows look as usual, except that they show mockup patient data. However, the local designer can change the windows. Right now he is working on the bronchoscopy window.

With *Ctrl* down, he has clicked one of the sample markers. He can see its properties. The *Width* property shows that the marker must be 14 pixels wide. The *BackColor* of the tag is given by a formula:

```
BackColor: Choose(result1+1, Color.LightGray, Color.LightGreen, Color.Yellow,
        Color.Red, Color.Aqua, Color.BlueViolet)
```

This means that the system must find a database row corresponding to the sample, take its *result1* field, and use it to select the color.

The system uses the *Rows* property to find the database rows to be used:

```
Rows: PtActivity Where parentPtActiID = param[1]
```

This means: Look into all patient activity rows in the database and find those that are related to this bronchoscopy. Param[1] is the identifier of this bronchoscopy.

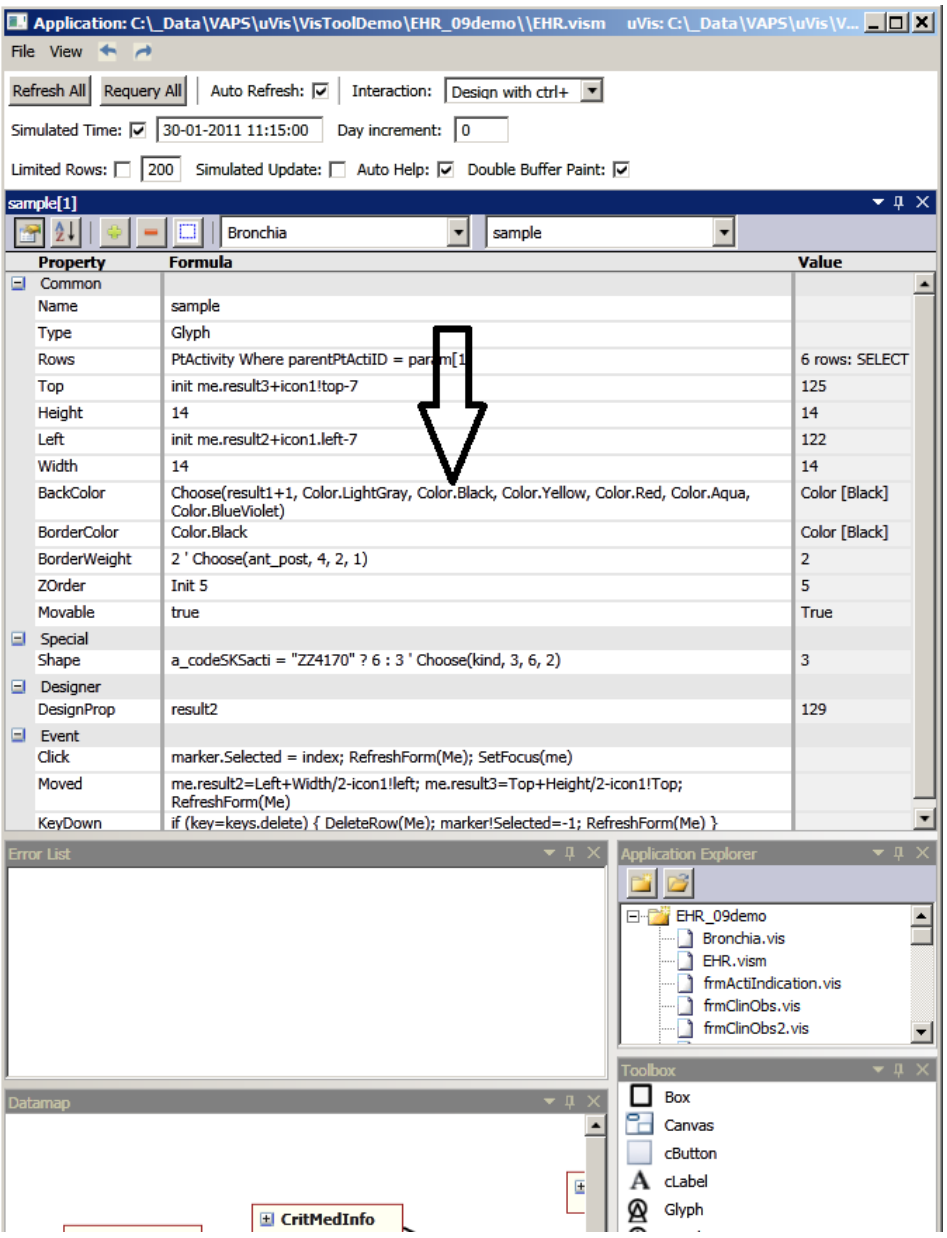
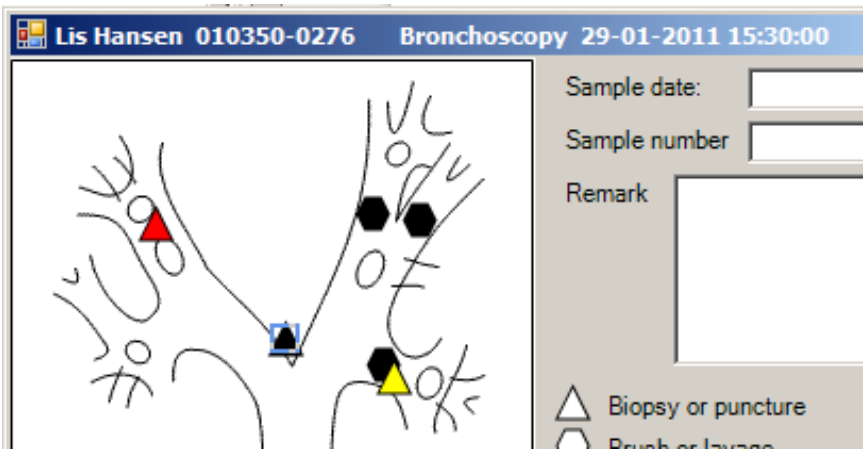
In this case the result is 6 activity rows. The system creates a marker on the screen for each of them and binds each tag to its database row. The *BackColor* formula finds "result1" in its row and uses it to paint the proper color. Other formulas use other fields of the row to calculate the position of the marker and to show the sample number, date, and the remark.

If the designer changes the *BackColor* formula so that *Color.LightGreen* becomes *Color.Black*, all the green samples immediately become black.

The local designer can add a new visual component to the window by dragging it from the Toolbox (lower right) and specifying its properties. He can immediately see whether it looks right. He can create a new window in the same way.

Everything in the VHR system is made in this way. When the new VHR version is okay, the designer transfers the window files to the operational system and the new version is ready for use.

uVisStudio



Bronchoscopy Window