Dummy Lab (DLab) Based On Dummyulation Using Identification Technologies

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Abstract

A new concept of Dummy Lab (DLab) and Dummyulation is proposed in the present article to bridge the gaps between physical practical labs and virtual practical labs which would be having a blend of personalization also. Presently, a plan is in progress for realization of barcode based and RFID based dummyulations.

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Abstract: A new concept of Dummy Lab (DLab) and Dummyulation is proposed in the present article to bridge the gaps between physical practical labs and virtual practical labs which would be having a blend of personalization also. Presently, a plan is in progress for realization of barcode based and RFID based dummyulations.

Keywords: SET, Practical Lab, Virtual Lab, Simulation, Identification Technologies, Barcode, RFID, Electrical/ Electronic Experiments

Introduction:

Physical Practical Lab (PLab) is an integral component of education in science/ engineering/ technology (SET) to enable the learners including students to do experiments in PLab to comprehend/ test further the concepts or theories. Infrastructures of PLabs are resource intensive. In addition, PLabs need physical presence of learners during a specified time interval under the guidance of trained staff. The conventional approach of PLabs has been now complemented by Virtual Labs (VLabs)[2-4] leveraging the proliferation of Information and Communication Technology (ICT) and significance of such VLabs has been severely experienced during recent pandemic of COVID. In VLabs, the learners can do experiments using computers and Internet connections where in the experiments are simulated virtually but not done physically. In a variant of VLabs, the physical experiments could be performed remotely where in a learner gets access to a remote PLab using ICT (many times augmented by technology of Robotics also) relaxing the constraint of physical presence of the learner in the PLab but which is at the same time much more resource intensive and expensive. Taking into account pros and cons of PLabs and VLabs, the present article is proposing a new approach of Dummy Lab (DLab) and Dummyulation with an aim of offering far improved learner experience along with a blend of personalization in a cost effective manner free from location or time constraints.

Proposed concepts of Dummy Lab (DLab) and Dummyulation:

As discussed earlier, it is evident that there is a gap between PLab-learner experience and VLab-learner experience. PLab offers hands-on experience and real feeling to learners enabling them to have best un-
derstanding of practical aspects of theories as well as the challenges which they could encounter with while using such experiences in further conceptualization of new theories, setting up of more refined practicals/advanced labs or future research and design in the concerned field. However, it lacks factors of personalization, affordability, ease of use, no chance of risk and no time constraint etc. being offered by VLabs. Though VLabs with remote control facility may offer access to resources of a Plab remotely, it still lacks merits of full blown hands on experience along with personalization, affordability, ease of use, no chance of risk and no time constraint.

In order to bridge the gap between PLabs and VLabs, new concepts of Dummy Lab (DLab) and Dummyulation are being proposed in the present article. In Dlabs, devices (including elements/ components, sources, generators, instruments, devices, systems etc.) would not be real, rather, they would be dummies of real devices having appearance, form factor, interface etc. of such a degree/dimension that the learners will feel as if they were using real devices though the dummy is nowhere close to the real one as far as the internal structure/implementation is concerned.

The learners would select different dummy devices as per the needs of their experiments, make connections, set parameters, perform experiments, note down the observations, receive feeble electric shocks, alarms, alerts, smoke etc. in case of not safe connections/improper connections and even get their devices virtually damaged (temporarily not functional) if mishandled . . . . . . very much similar to what they might experience in a PLab.

In fact, objective of the concept of DLab is to complement the concept of VLab based on simulation i.e. Dummyulation. Dummyulation may be defined as Simulation combined with automatic interactions with Dummies of Real Entities participating in the simulation. It seems very likely that the initial early phase of realization of DLABs based on Dummyulations could become soon a turning point for STE education as far as issues of labs are concerned. It can be easily guessed that the full blown DLABs could be a determining factor in en masse training of the technical workforce in sectors other than that of academics in the coming future. It would in turn result in a sort of new big market of DLABs having promising potential of generating large number of new jobs.

As dummyulations need simulations to have interactions with dummies with least human intervention, it immediately raises concerns of how to export the topology of real circuit using dummies to simulator, make simulations to get inputs from certain dummies or send certain simulated data to the dummies in need. Out of many possible approaches, one approach being proposed here is that of one based on use of Identification Technologies viz. Barcode, QRcode, and RFID etc. In the following sections, first dummyulation for certain experiments assuming no frequent or fast interactions with simulation along with certain level of human intervention is discussed. Later on, many such assumptions are relaxed or dropped, and dummyulations for such scenarios are also discussed.

**Dummyulation using Barcodes**

Barcode is one of the very popular identification technologies wherein identification of certain entity is printed on a surface in form of black and white bars with varying thickness and space between bars which are read by a barcode reader by recording the pattern of reflection of light from barcode once the barcode is illuminated by the barcode reader. The read sequence of digits is used to identify the entity for further processing.

Example 1: In Figure 1, a bar code is displayed which represents the following sequence of digits:

0123456789012
Figure 1: Image of a barcode [1]

This sequence of digits could be used as Identification of an entity having association with the barcode. An entity could be a dummy itself, one of its ports/terminals or state of the dummy. If all such entities are assigned unique barcodes, the IDs of the entity and its ports along with its state could be read and transferred to a file in a PC wherefrom it could be consumed for further processing to generate simulated topology of the circuit being investigated, to compute certain quantities being measured, and to communicate computed values of measurement to the concerned dummies responsible for displaying the measured value/signal.

Example 2:
Let 10-digit barcode \texttt{MSD9 MSD8 MSD7 MSD6 MSD5 MSD4 MSD3 MSD2 MSD1 MSD0} (\texttt{MSDx} represents the \(x^{th}\) most significant digit) is being used for dummyulation and the fields being represented by digits are as follows where in Null Barcode (NULLBC) is defined as 0 0 0 0 0 0 0 0 0 0 and Stop Barcode (STOPBC) is defined as 9 9 9 9 9 9 9 9 9 9:

- \texttt{MSD9}: D/P/S Flag (Device/Port/State Flag: if it is set as 1 it identifies a Device, else if 2 it identifies one of its ports, else if 3 it represents its state)
- \texttt{MSD8 MSD7}: Device Type
- \texttt{MSD6 MSD5}: Device Number

\textbf{if D/P/S Flag is set 1}
\texttt{MSD4, MSD3, MSD2, MSD1, MSD0} are all necessarily 0 and the corresponding device is having barcode ID as \texttt{MSD9 MSD8 MSD7 MSD6 MSD5 0 0 0 0 0}

\textbf{else if D/P/S Flag is set 2}
\texttt{MSD4 MSD3 MSD2 MSD1 MSD0} is ID of one of ports of the device having barcode ID as \texttt{MSD9 MSD8 MSD7 MSD6 MSD5 0 0 0 0 0}

\textbf{else if D/P/S Flag is set 3}
\texttt{MSD4 MSD3 MSD2 MSD1 MSD0} represents the state of the device having barcode ID as \texttt{MSD9 MSD8 MSD7 MSD6 MSD5 0 0 0 0 0}
So, barcode 1223300000 represents Device ID of a device of TYPE=22 with Device Number=33.

Similarly, barcode 2223300000 means ID of the port with PORT NUMBER=00000 of the device with Device ID 1223300000 and barcode 2223300005 means the ID of the port with PORT NUMBER=00005 of the device with Device ID 1223300000.

Also, barcode 3223312345 means the state of the device with Device ID 1223300000 is STATE=12345.

Example 3: A circuit of dummies of a voltage source, a resistor and a voltmeter is shown in Figure 2.

<table>
<thead>
<tr>
<th>+ve Terminal BC01 &lt;01&gt; IIIIIIII</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 V DC Voltage Source (DCVS) BC02</strong> &lt;05&gt; IIIIIIII</td>
<td></td>
</tr>
<tr>
<td><strong>State Value=4 V (Output of DCVS is set as 4 V)</strong> BC03 &lt;06&gt; IIIIIIII</td>
<td></td>
</tr>
<tr>
<td>-ve Terminal BC04 &lt;08&gt; IIIIIIII</td>
<td>B</td>
</tr>
</tbody>
</table>

**Dummy of a DC Voltage Source**

<table>
<thead>
<tr>
<th>Terminal-1 BC05 &lt;02&gt;&lt;07&gt; IIIIIIII</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Resistor (RESTR) BC06</strong> &lt;01&gt; IIIIIIII</td>
<td></td>
</tr>
<tr>
<td><strong>State Value=1 ohm (Value of RESTR is 1 ohm)</strong> BC07 &lt;01&gt; IIIIIIII</td>
<td></td>
</tr>
<tr>
<td>Terminal-2 BC08 &lt;04&gt;&lt;09&gt; IIIIIIII</td>
<td>D</td>
</tr>
</tbody>
</table>

**Dummy of a Resistor (1 ohm)**

<table>
<thead>
<tr>
<th>+ve Terminal/ Probe BC09 &lt;08&gt; IIIIIIII</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DC Voltmeter (DCVM) BC10</strong> &lt;11&gt; IIIIIIII</td>
<td></td>
</tr>
<tr>
<td><strong>State Value=10 V (Range of DCVM is set as 10 V)</strong> BC11 &lt;12&gt; IIIIIIII</td>
<td></td>
</tr>
<tr>
<td>-ve Terminal/ Probe BC12 &lt;10&gt; IIIIIIII</td>
<td>F</td>
</tr>
</tbody>
</table>

**Dummy of a DC Voltmeter**

Figure 2: A circuit of dummies of a voltage source, a resistor and a voltmeter; <x> represents the sequence number when the associated barcode is read, <x><y> indicates that the associated barcode is read two times first with sequence number as <x> and second time with sequence number as <y>.

In Figure 2, dummies of a 5 V DC Voltage Source (DCVS) set at 4 V with A and B as its +ve and –ve terminals respectively, a Resistor (RESTR) of 1 ohm with C and D as its terminals and a DC Voltmeter (DCVM) set for its range as 10 V with E and F as its +ve and –ve terminals/probes respectively are used to demonstrate how the physical circuit of these dummies could be translated into simulated topology of the circuit. Steps for reading the barcodes are as follows:

S1: Read the NULL BC (NULLBC)
S2: Read the BC next in sequence  
S3: Read the BC next in sequence  
S4: If the BC having last sequence number is read GOTO S5 else GOTO S1  
S5: Read the Stop BC (STOPBC)  

After reading of all BCs is done in a file namely Example.xyz, the file may display a table as follows:

<p>| | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NULLBC</td>
<td>BC01</td>
<td>BC05</td>
<td>NULLBC</td>
<td>BC04</td>
<td>BC08</td>
<td>NULLBC</td>
<td>BC05</td>
<td>BC09</td>
<td>NULLBC</td>
</tr>
<tr>
<td></td>
<td>BC08</td>
<td>NULLBC</td>
<td>BC05</td>
<td>BC09</td>
<td>NULLBC</td>
<td>BC08</td>
<td>BC02</td>
<td>NULLBC</td>
<td>BC06</td>
<td>BC07</td>
</tr>
<tr>
<td></td>
<td>BC08</td>
<td>BC10</td>
<td>NULLBC</td>
<td>STOPBC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each pair of barcodes (BCm, BCn) lying between two consecutive NULLBCs would represent a connection between the two terminals associated with BCm and BCn provided both BCm and BCn are having D/P/S Flag set as 2.  

Each pair of barcodes (BCm, BCn) lying between two consecutive NULLBC would represent a state value of a device provided neither BCm nor BCn is having D/P/S Flag set as 2. If BCm (BCn) is having D/P/S Flag set as 1 and BCn (BCm) is having D/P/S Flag set as 3 then BCn (BCm) would represent the state value of the device having barcode ID as BCm (BCn).  

At the end of the file when STOPBC is encountered, the simulator would simulate the topology of the circuit for display and compute the state value(s) of the corresponding measuring/ display device(s). The simulated topology of the circuit and reading of the DCVM for the present example would be as follows:  

D  

**Reading of DCVM (BC11): 4 V**  

This measured value may be communicated to the dummy of DCVM to display 4 V on its display panel.

Suppose the experiment is repeated but now DCVM is set as 1 V i.e. BC12 represents state value of the DCVM (BC11) as 1 V.
Then the simulated topology of the circuit and reading of the DCVM for the present example would be as follows:

**Reading of DCVM (BC11):** *Error – Your DCVM is damaged which may be accompanied by a sort of real short smoke pulse/ buzzer or a Warning - the quantity being measured is out of range*

The same concept could be extended for other circuits having a large number of components of varying features/ parameters.

**Dummyulation using RFID Technology:**

As discussed earlier, barcodes could be supplemented by semi passive/ active RFID tags. As a result interactions between circuit of dummies and simulator would not suffer what barcode based dummyulation does in case of more real/ complex and demanding circuits. The Instant of Time to Speak (ITS) for an RFID tag could be decided using a timer that would generate a pulse of sufficient duration starting at $T_N$ to enable the RFID tag with its sequence number as $<N>$ to speak for dummies-to-simulator communication. Barcodes NULLBC and STOPBC would be having NULLTI (NULL Time Interval) and STOPTI (STOP Time Interval) RFID counterparts respectively.

**Pros:**

1. Non Line Of Site (NLOS) Communication
2. Automatic
3. Fast
4. May result in less space requirement
5. The same technology of RFID could be used for bidirectional communication that is the same RFID technology will be used for communication from dummies to the simulator and vice versa
6. If the state values of input devices are changing frequently, the simulation could cope up with the changes in inputs in almost real time.
7. Dummies of output devices like oscilloscope etc. are feasible.
8. For simulator to dummies communication, RFID reader can communicate asynchronously to the RFID tags of intended dummies.
9. More complex and close to real dummies and dummyulations are feasible for electrical/ electronic experiments.
10. The same concept could be used for certain other non electrical/ non electronic experiments.
11. Far improved learner experience

**Cons:**

1. RFID Reader is required which could be expensive
2. Power hungry as compared to barcodes
3. RFID tags are required to be customized with the help of timers so that they could know when to speak. It necessitates requirement of sufficiently large number of miniaturized and cost effective timers.

**Conclusion:**

As proposed and illustrated earlier, it is evident that the concept of DLab and Dummyulation are useful and realizable for the learners and the SET institutions. The learners can do their experiments as per their convenience irrespective of time or space constraints. At the same time institutions would be more relaxed from burden of investing significantly on PLabs or from the problem of insufficient infrastructure for PLabs. In addition, premium resources could be used more optimally and safely by hands pre-trained through dummyulations. The concepts of DLab and Dummyulation seem promising to be embraced by the non academic SET organizations also for the purpose of training and research & development (R&D). The communications between dummies and simulator could be having varying implementations. One such implementation is that of using barcodes which seems suitable for the set of experiments requiring no or low frequent changes in the
Topology of the circuits or state values of dummies. Barcode based dummyulation is asymmetric in the sense that it is meant for communication from dummies to simulator only. It is required to be complemented by a non barcode communication technology for communication from simulator to dummies. RFID technology could be more suitable for supplementing the barcode technology for dummyulation for the set of dynamic experiments requiring frequent changes in topology or state values as RFID based dummyulation is fast, automatic and symmetric. A variety of other approaches may be conceptualized and implemented in future. One such promising technology could be, perhaps, IPCD (Image Processing of Circuit of Dummies) wherein image of a circuit of dummies could be processed to feed simulators. Presently, a plan is in progress for realization of barcode based and RFID based dummyulations.

References: