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SYNTAX : MISSION TIME LINEAR TEMPORAL LOGIC. (MLTL)

$$\phi ::= \textbf{true}|\textbf{false}|\textbf{p}|\neg\phi \mid \phi \wedge \psi \mid \phi \vee \psi \mid \phi\Box_{\mathbf{I}}\psi \mid \phi\Diamond_{\mathbf{I}}\psi \mid \phi\ \mathbf{U}_{\mathbf{I}}\psi \mid \phi\ \mathbf{R}_{\mathbf{I}}\psi$$

A MLTL formula ϕ, over a set of propositions AP, by a computation trace π starting from position i (denoted as $\pi, i \models \phi$) has satisfaction recursively defined as follows:

$\pi, i \models$ true

$\pi, i \models p$ iff $p \in \pi[i]$

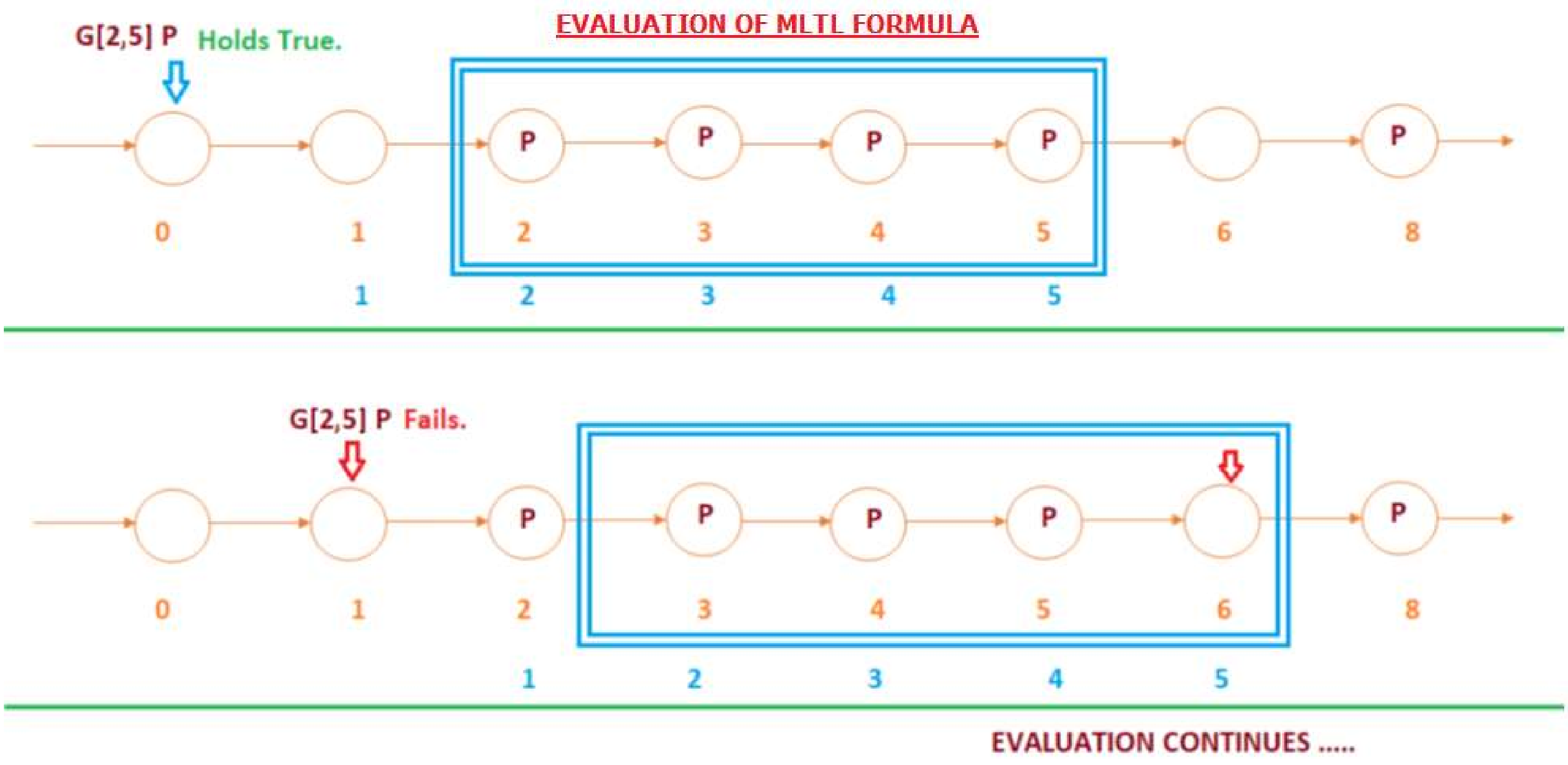
$\pi, i \models \neg\phi$ iff $\pi, i \not\models \phi$

$\pi, i \models \phi_1 \wedge \phi_2$ iff $\pi, i \models \phi_1$ *and* $i \models \phi_2$

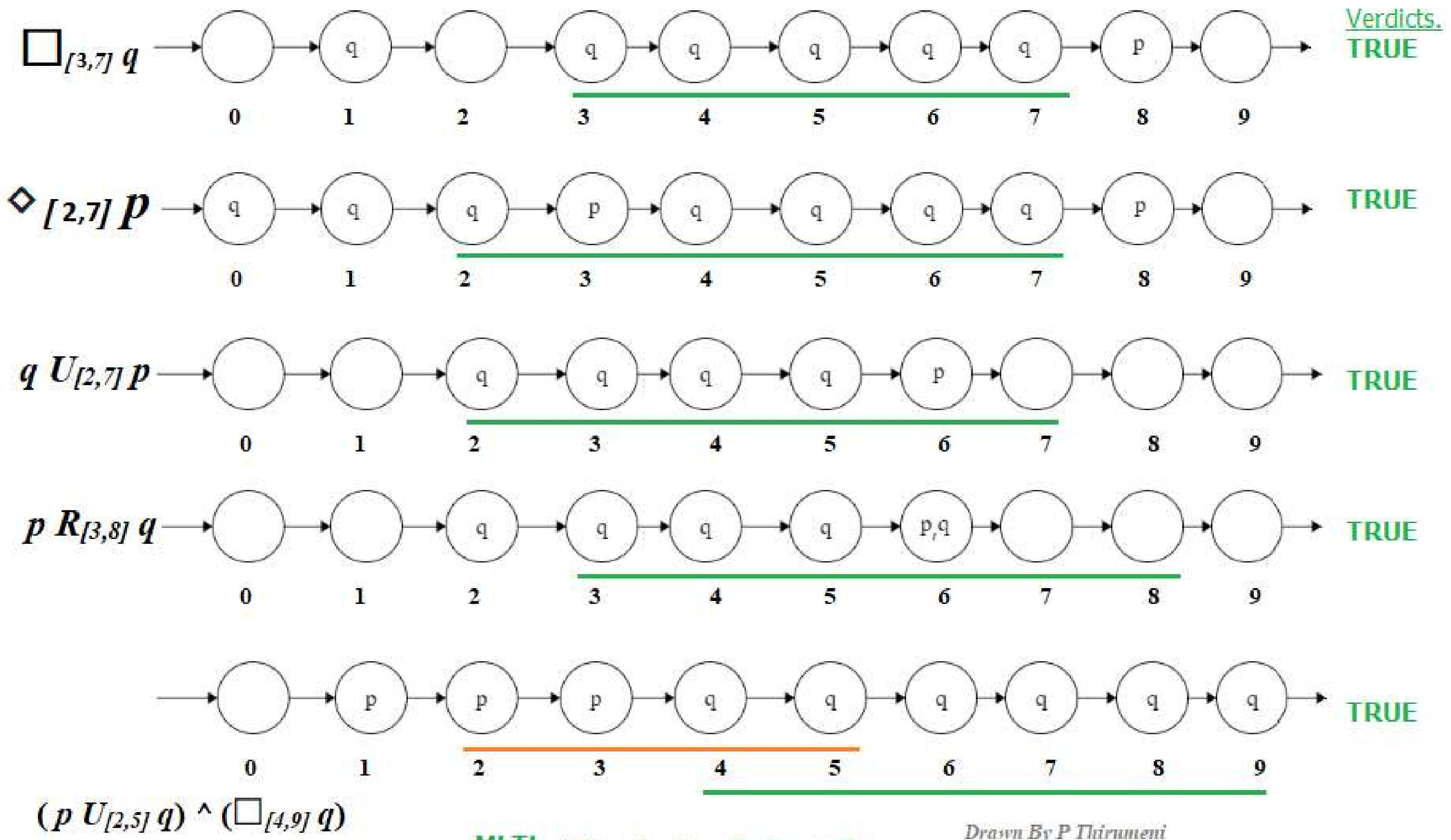
$\pi, i \models \phi_1 U_{lb,ub} \phi_2$ iff $|\pi| \geq i + lb$ and, there exists $j \in [i+lb, i+ub]$ such that $\pi, j \models \phi_2$ and for every $k < j$, $k \in [i + lb, i + ub]$, $\pi, k \models \phi_1$.

Ref: Cite[10]

MISSION TIME LINEAR TEMPORAL LOGIC. (MLTL)



MISSION TIME LINEAR TEMPORAL LOGIC. (MLTL)

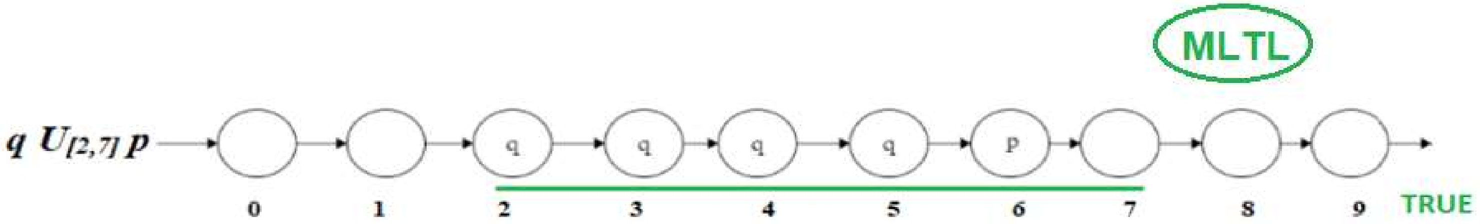


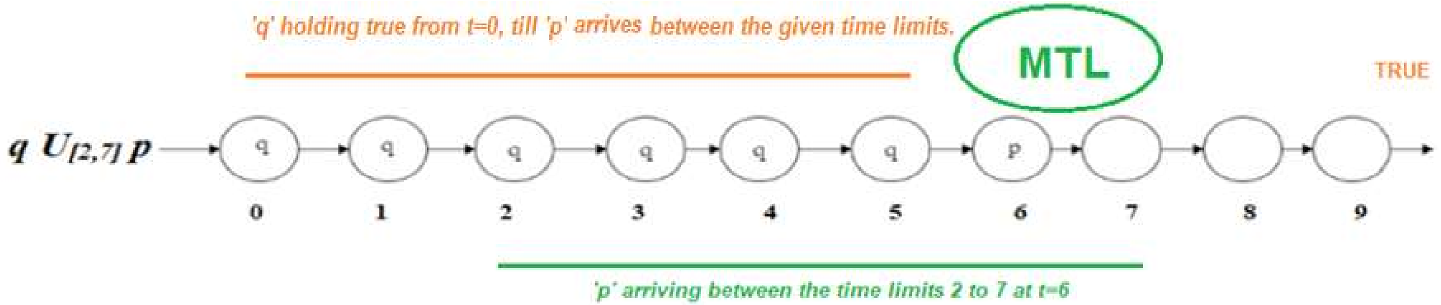
MLTL- *(All evaluations for time =0)*

Drawn By P Thirumeni

Ref: Cite[2]

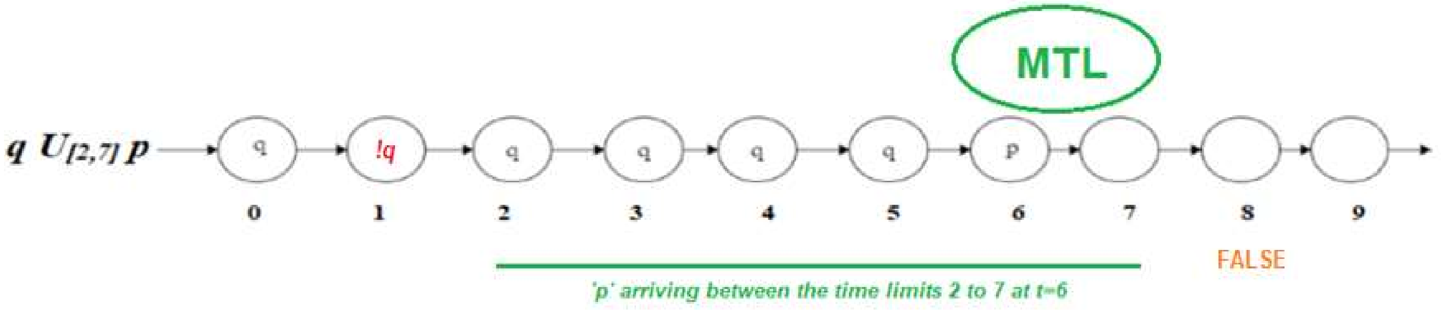
UNTIL OPERATOR, MLTL VS MTL




'q' holding true from t=0, till 'p' arrives between the given time limits.

'p' arriving between the time limits 2 to 7 at t=6

Citation paper ref [11], point 115



'p' arriving between the time limits 2 to 7 at t=6

BMS SYSTEM – MLTL SPECIFICATIONS.

Property -1 : The BMS system should maintain the battery bank's DC terminal voltage, always at Vcc. (the mission time =50000 time units)

MLTL spec:

```
INPUT

   vcc: bool;

FTSPEC

G[0,50000]   vcc ;
```

User's observing program:

The user's program should monitor the output verdicts, of the above MLTL specification from 0 to 50000 time units, later verdicts, it may ignore. In case of property holding true a single TRUE verdict will be outputted after 50000 time units.

In case of failure, wherever the AP does not hold (between 0 to 50000), the verdict FALSE will be outputted immediately, So the user shall be looking for a FALSE verdict as failure event.

BMS SYSTEM – MLTL SPECIFICATIONS.

Property - 2: The BMS system should start recharging as soon as the terminal voltage falls below the Voltage low threshold (V low = 11V) and reach the terminal voltage (Vcc=12V) within the minimal recharge time (30 minutes). The monitoring time window shall be enough for the system to realise the property.

MLTL spec:

INPUT

```
    vcc,vlow : bool;
```

FTSPEC

```
G[0,50000]  ( (vlow)  → F[18000] (!vlow  &&  vcc) )
```

If the property holds true at the end of the mission (at time = 50001) the verdict will be ‘1’, in case of failure a ‘0’ will be output as verdict wherever the property fails (between t=0 to t=50000), the user program should look for a false or ‘0’ output to take corrective measure in case of failure.

BMS SYSTEM – MLTL SPECIFICATIONS.

Property - 3 : For every 4 time units the BMS module should enable CANTX for transmitting the status of all the parameters via the CAN bus. (CANTX, UP enable realization time considered less than the time granularity of monitor here.)

```
INPUT

   CANTX: bool;


FTSPEC


G[0,49999] ((CANTX -> G[4,4] CANTX) && (CANTX -> (G[1,3] ! CANTX)));
```

Ref. [10,page 3, definition – 1.], for G[4,4]

BMS SYSTEM – MLTL SPECIFICATIONS.

Property - 4 : one power source should be in connected state to the power bus (Either the solar power or the Battery power),at any given time, and both power source should not be paralleled at any given time.

INPUT

```
psol, pbat : bool;
```

FTSPEC

```
G[0,50000] ( ! ( psol && pbat ) &&  ( (psol && !pbat)  | | (!psol && pbat) ) )
```

The user's program should monitor the output from time =0 till time=50000, if the property fails the verdict will be '0' and immediately outputted, if the verdict is true that is if the property holds true, the verdict will be '1' at the end of the mission.

Typically, the user program should be looking for an '0' which is a failure case. Once a '0' verdict is received it can take appropriate action for breach of this property.

BMS SYSTEM – MLTL SPECIFICATIONS.

Property – 5 : During entire mission time if the battery temperature is reaching more than 50 deg. Centigrade, then it should be either due to an increase in ambient temperature beyond 45 deg.C, or battery power output exceeding 75%.

INPUT

```
btem50,atem45,out75: bool;
```

FTSPEC

```
G[0,50000] (  (btem50) ->  ( (atem45)   | | (out75) ) );
```

The user program shall observe a TRUE verdict in the mission time range for a correct operation.