Temporal Reasoning with OpenCog

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SingularityNET & OpenCog Foundations

Why Temporal Reasoning?

1. Lag between cause and effect
2. Meta-reasoning: Think about think about think about think about ...

PLN Recall

P, Q, ...: $Atom^n \rightarrow \{True, False\}$

`And <TV>`
`  P`
`  Q`
	$\equiv$	$\mathcal{P}(P, Q) \approx TV.strength$

`Not <TV>` `  P`	$\equiv$	$\mathcal{P}(P) \approx 1 - TV.strength$

`Implication <TV>`
`  P`
`  Q`
	$\equiv$	$\mathcal{P}(Q\|P) \approx TV.strength$

PLN rules: Implication Direct Evaluation

```
Evaluation
  P
  Ei
...
Evaluation
  Q
  Ei
|-
Implication <TV>
  P
  Q
```

$$TV.strength = \frac{\sum_x f_\wedge(P(x).strength, Q(x).strength)}{\sum_x P(x).strength}$$

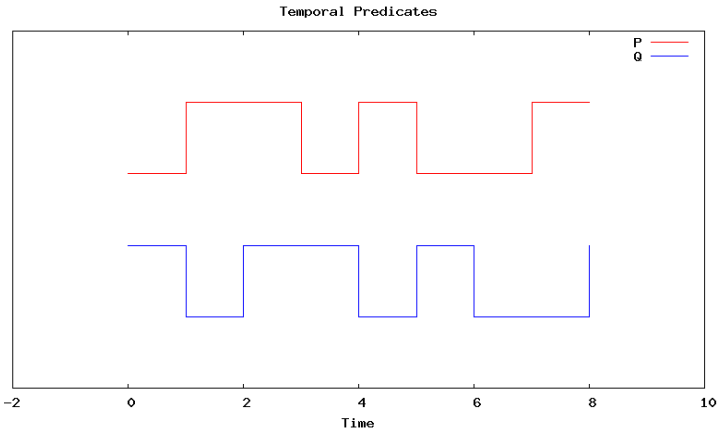
PLN rules: Deduction

```
Implication
  P
  Q
Implication
  Q
  R
|-
Implication <TV>
  P
  R
```

$$TV.strength = \mathcal{P}(R|Q,P) \times \mathcal{P}(Q|P) + \mathcal{P}(R|\neg Q,P) \times \mathcal{P}(\neg Q|P)$$

Temporal Predicate

$$P : Atom^n \times Time \rightarrow \{True, False\}$$



LagLink and LeadLink

- Lag: brings past into present

```
LagLink
  P
  T
```

≡

```
LambdaLink
  x, t
  P(x, t-T)
```

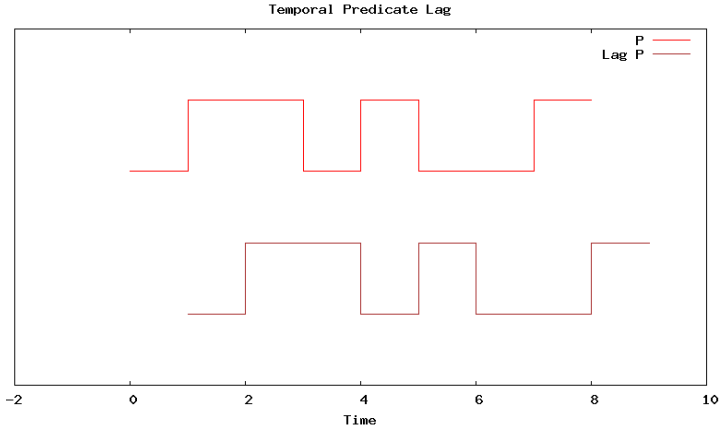
- Lead: brings future into present

```
LeadLink
  P
  T
```

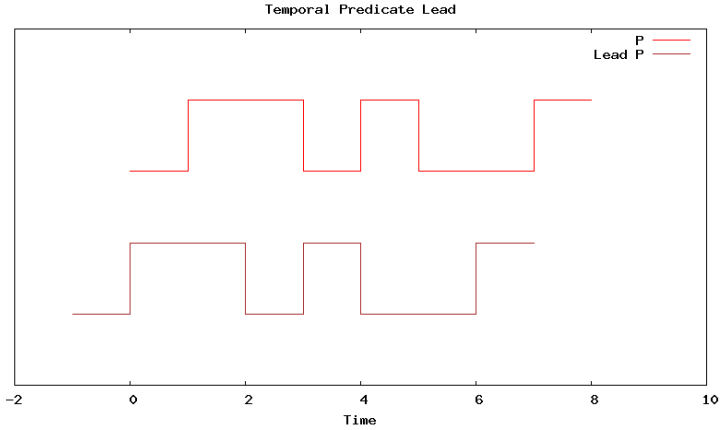
≡

```
LambdaLink
  x, t
  P(x, t+T)
```

Lag: example



Lead: example



SequentialAnd

```
BackSequentialAnd <TV>
  T
  P
  Q
```

≡

```
And <TV>
  Lag
    P
    T
  Q
```

```
ForeSequentialAnd <TV>
  T
  P
  Q
```

≡

```
And <TV>
  P
  Lead
    Q
    T
```

PredictiveImplication

```
BackPredictiveImplication <TV>
  T
  P
  Q
```

≡

```
Implication <TV>
  Lag
    P
    T
  Q
```

```
ForePredictiveImplication <TV>
  T
  P
  Q
```

≡

```
Implication <TV>
  P
  Lead
    Q
    T
```

PredictiveImplication

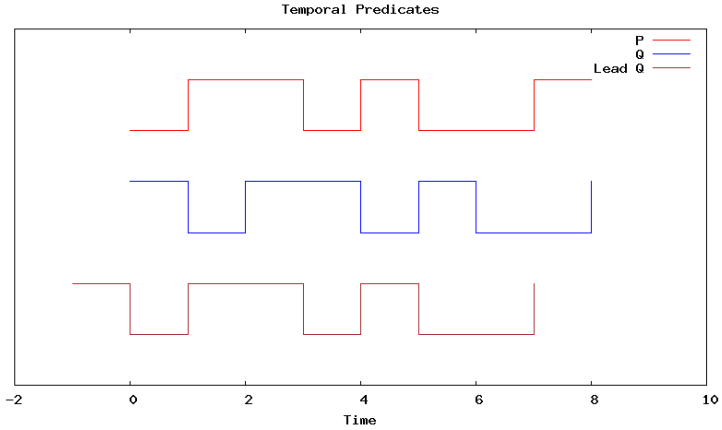
```
BackPredictiveImplication <TV>
  T
  P                          ≡
  Q
```

```
Implication <TV>
  Lag
    P
    T
  Q
```

```
ForePredictiveImplication <TV>
  T
  P                          ≡
  Q
```

```
Implication <TV>
  P
  ForeSequentialAnd
    T
    P
    Q
```

???


Temporal Predicates
P
Q
Lead Q
−2
0
2
4
6
8
10
Time