UNIVERSITY OF AGRICULTURE
IN KRAKOW

# DECISION SUPPORT MODEL FOR DAIRY COW MANAGEMENT

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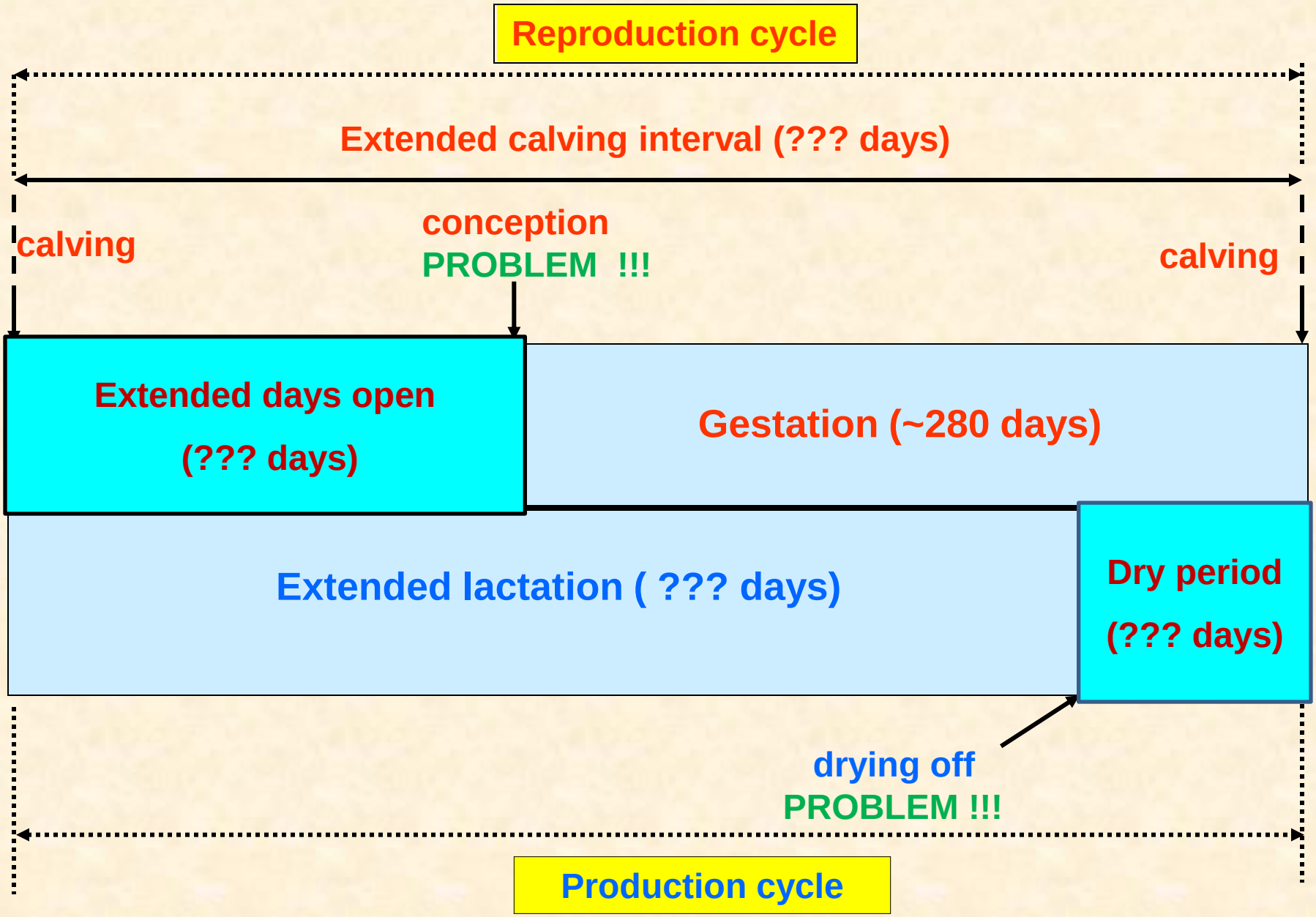
# HIGH YIELDING COWS – DECISION PROBLEM



# DAIRY COW MANAGEMENT

**(sequential decision problem)**

## DECISIONS:

- **Age at first breeding – when to inseminate a heifer ?**
- **Length of days open period – when to inseminate a cow after calving ?**
- **Length of dry period – when to dry a cow ?**
- **Time of replacement – when to replace a cow with a heifer?**

**To support the economically optimal decisions on dairy cow management**

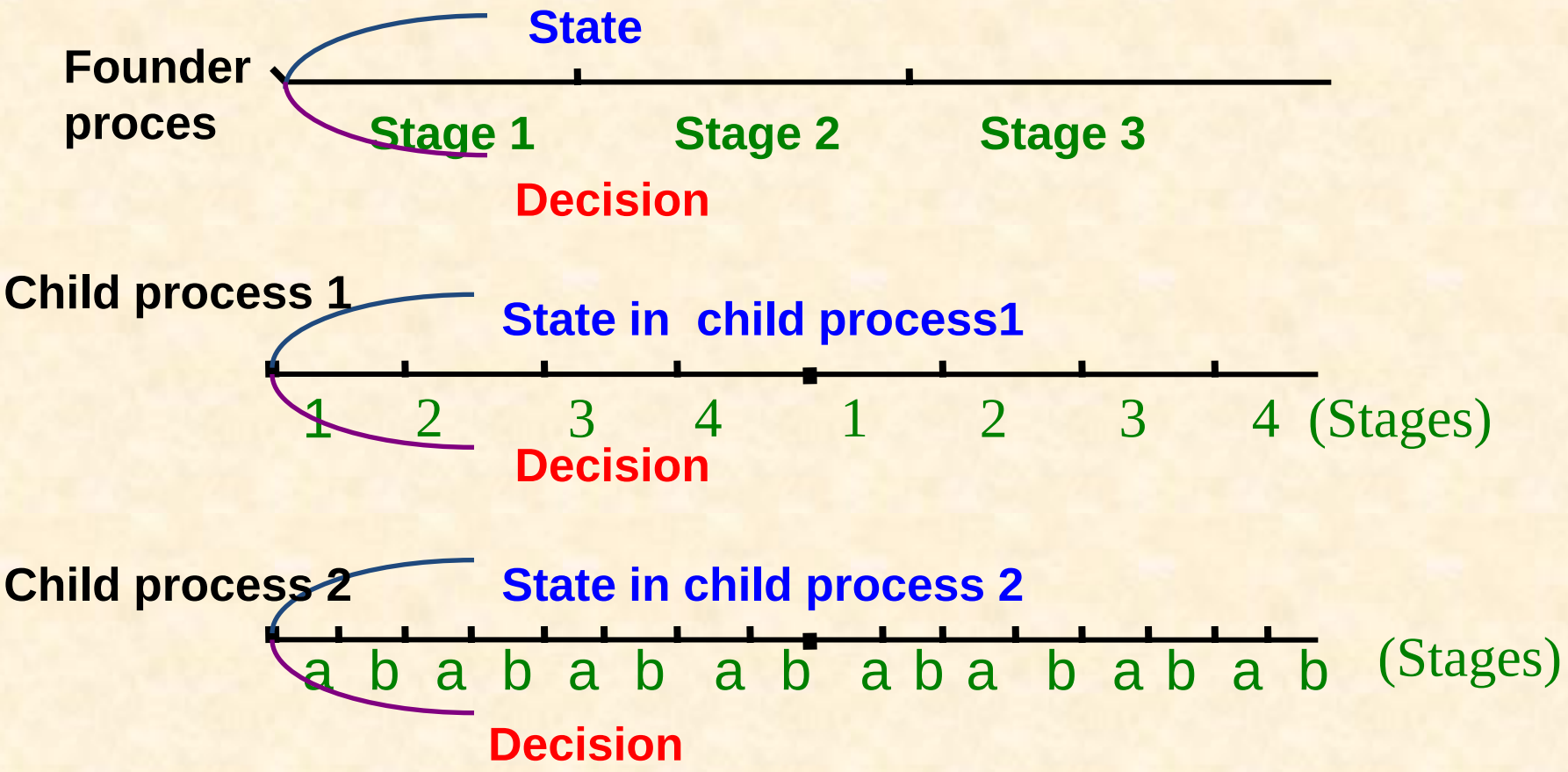
**DYNAMIC PROGRAMMING MODEL**

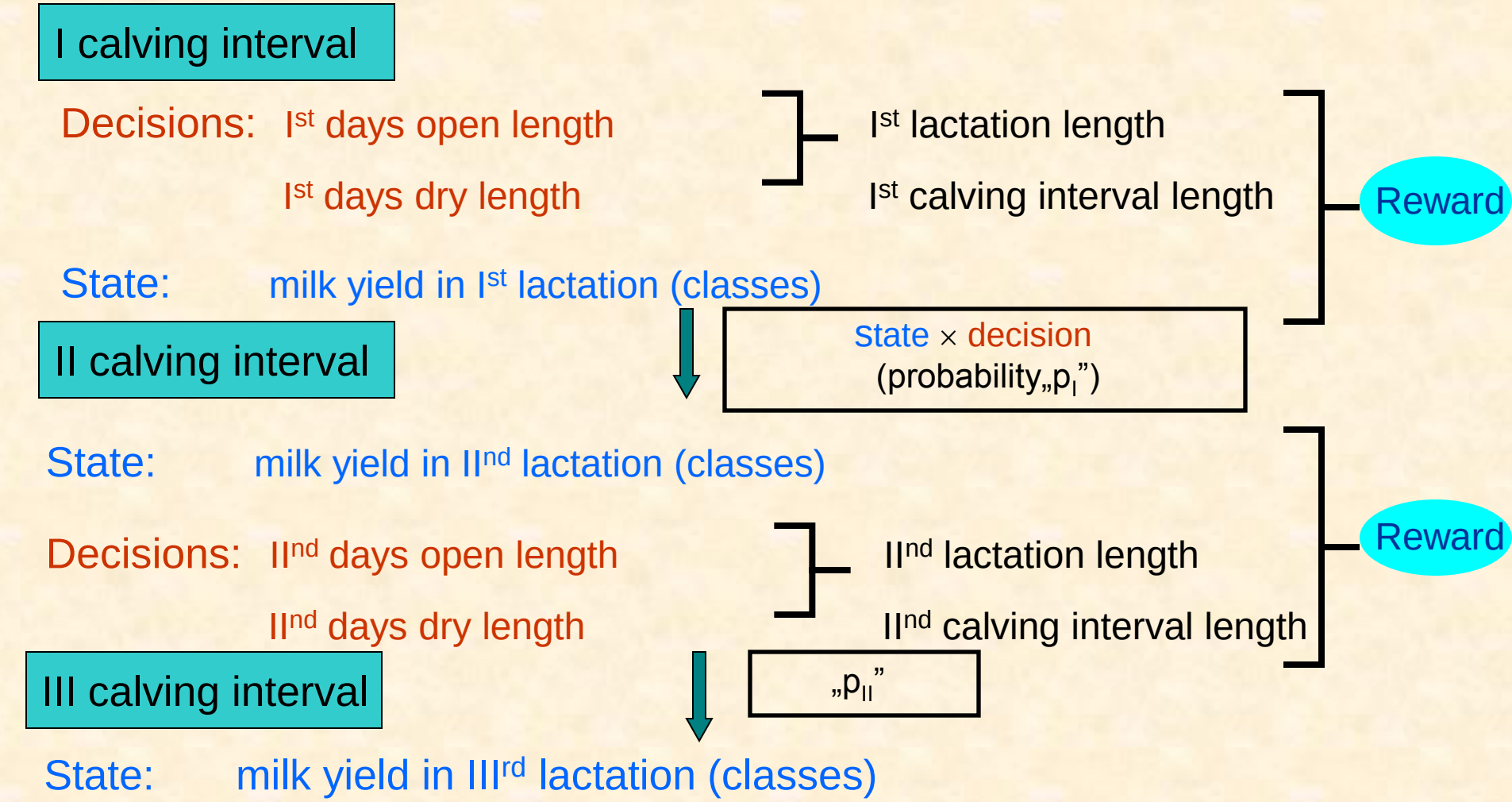
**was developed.**

**Multi-level hierarchic Markov decision process (MLHMP)**

(Kristensen and Jørgensen, 2000)

# Multi-level hierarchic Markov process (MLHMP)






**Decision:** replace a cow with a heifer (after I, II, III...lactation) ???

⇒ Constraints : minimum length of days open period

minimum length of dry period ???

# Objective function

## (criterion of optimality)

**maximization**

**of the expected discounted net revenues per cow**

# Estimation of parameters -

## based on empirical data and literature information

- **Data from milk recording of 5104 Holstein – Friesian cows (13 997 lactations) maintained in the three leading dairy farms in Poland**
- **Expected milk production – lactation curve based on test-day records** (according to Wilmink,1987)
- **Reproduction data (insemination, calving)**
- **Involuntary culling data (disposal)**
- **Economic data (prices, costs)**

Uncertainty in the reproduction and production processes is taken into account by calculating relevant **transition probabilities.**

# Economic data

| Revenues | Costs |
|---|---|
| Milk production | Replacement heifer (calved) |
| Calf sales | Insemination |
| Carcass value of replaced cow | Veterinary costs |
| | Milking |
| | Feed |
| | |

**Constructing and editing of the model,**

**finding the optimal strategy of dairy cow management**

**and simulation technical and economic consequences**

**of different optimal and non-optimal policies**

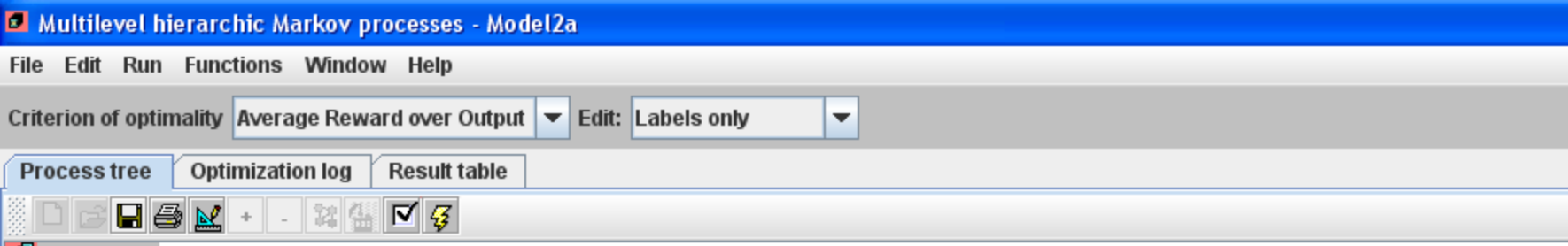
## The Multi-Level Hierarchic Markov Processes (MLHMP)

## Java software system

(Kristensen, 2003)

**The model structure and parameters were defined in „plug-in” of MLHMP software**

**The plug-in integrates the model structure, the transition probabilities and biological, production and economic parameters with the MLHMP platform used to compute the optimal policy.**

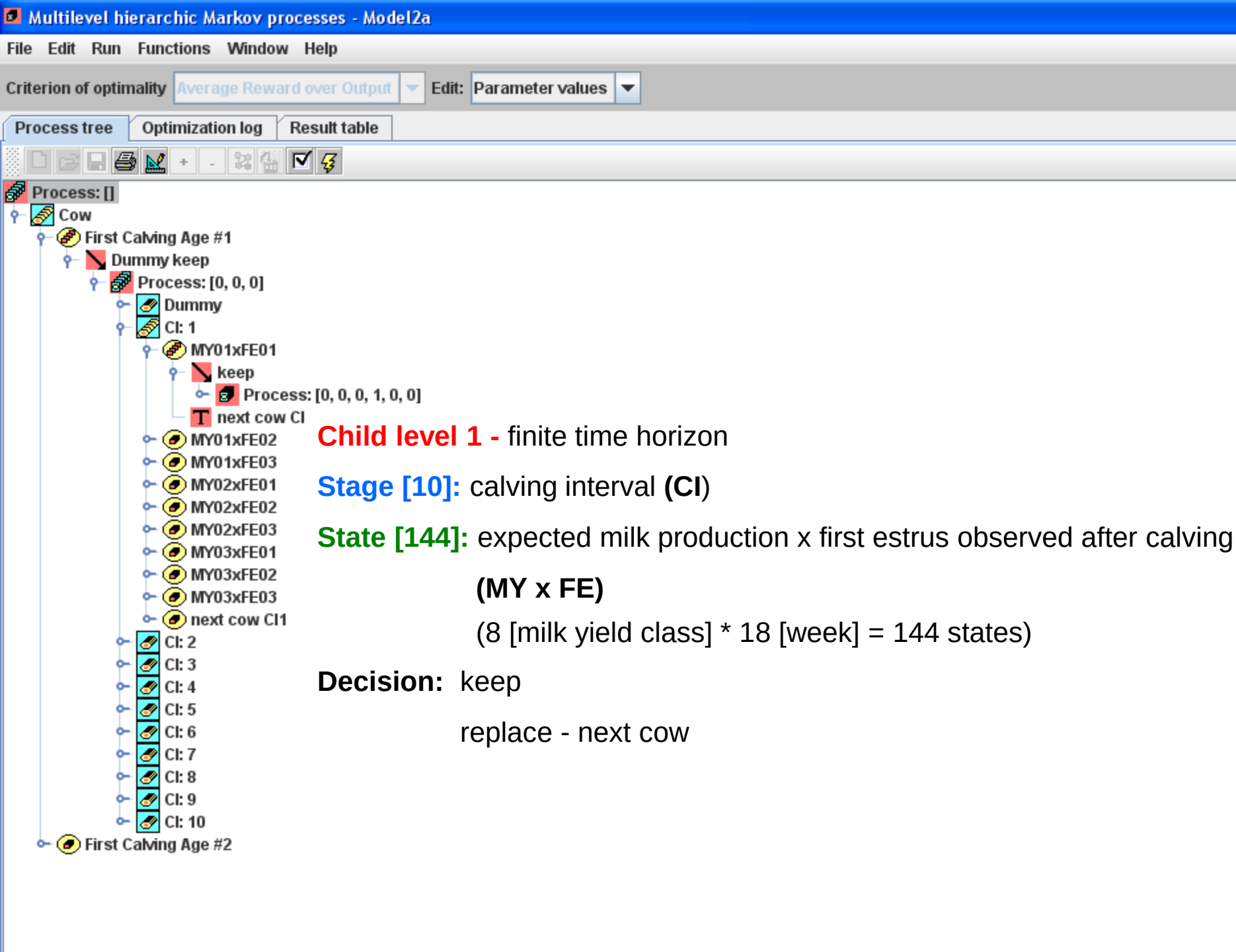



**Founder process -** infinite lifetime horizon

**Stage:** lifetime of a cow no 1, 2, 3 ….

**State [3]:** age at first calving

(3 classes: ≤ 792, 793-928,≥ 929 days)




**Child level 1 -** finite time horizon

**Stage [10]:** calving interval **(CI)**

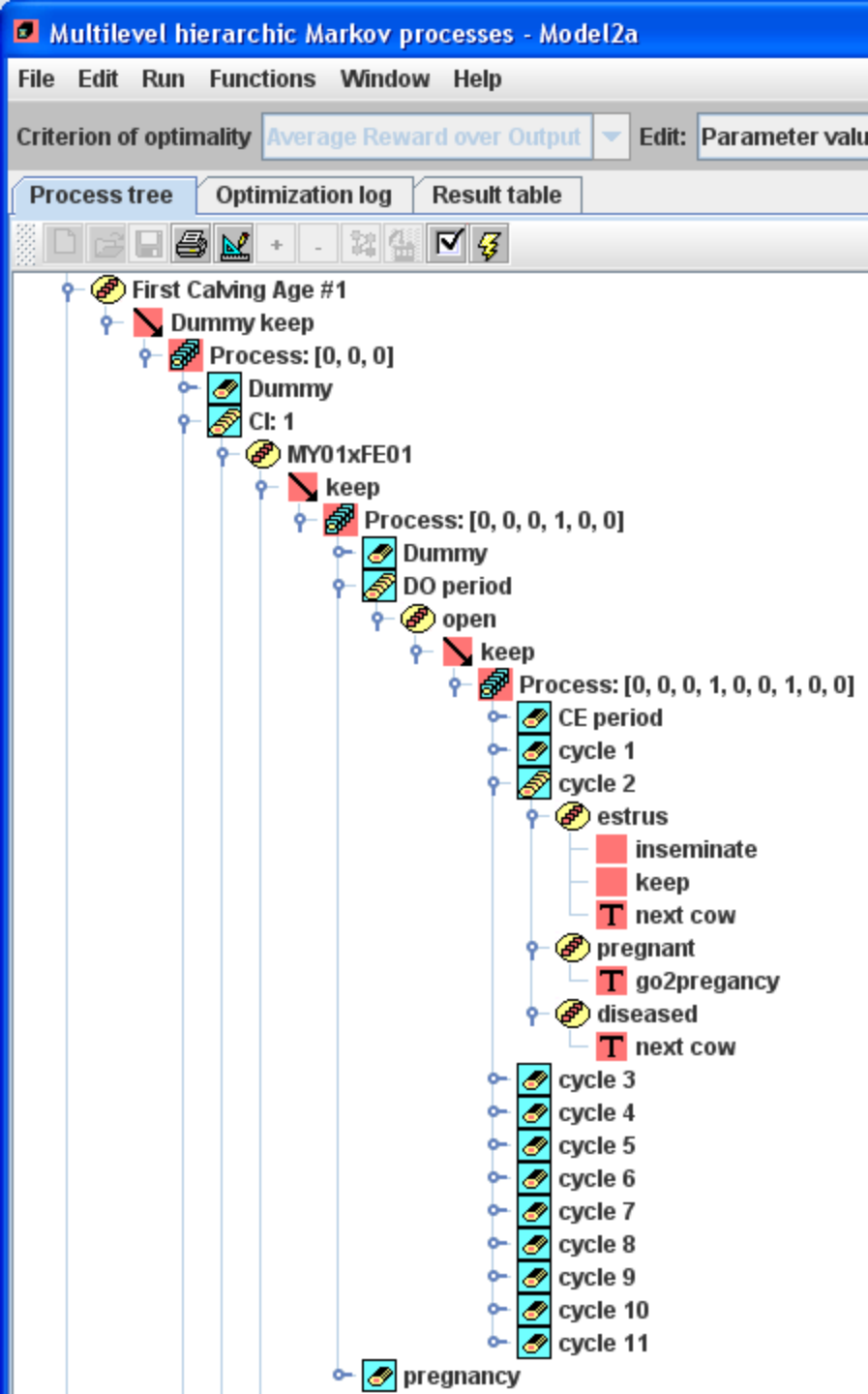
**State [144]:** expected milk production x first estrus observed after calving

**(MY x FE)**

(8 [milk yield class] * 18 [week] = 144 states)

**Decision:** keep

replace - next cow




**Child level 2 -** calving interval

**Days open**

**Stage [1]:** calving-estrus period **(CE)**

- rest after calving (5 weeks)

**State :** open - anestrus

**Decision :** keep

**Stage [11]:** estrus cycle (3 weeks)

**State:** estrus (observed) in 1-10 estrus cycle

**Decision:** inseminate (6-30 week), keep, replace

**State:** estrus (observed) in 11 estrus cycle

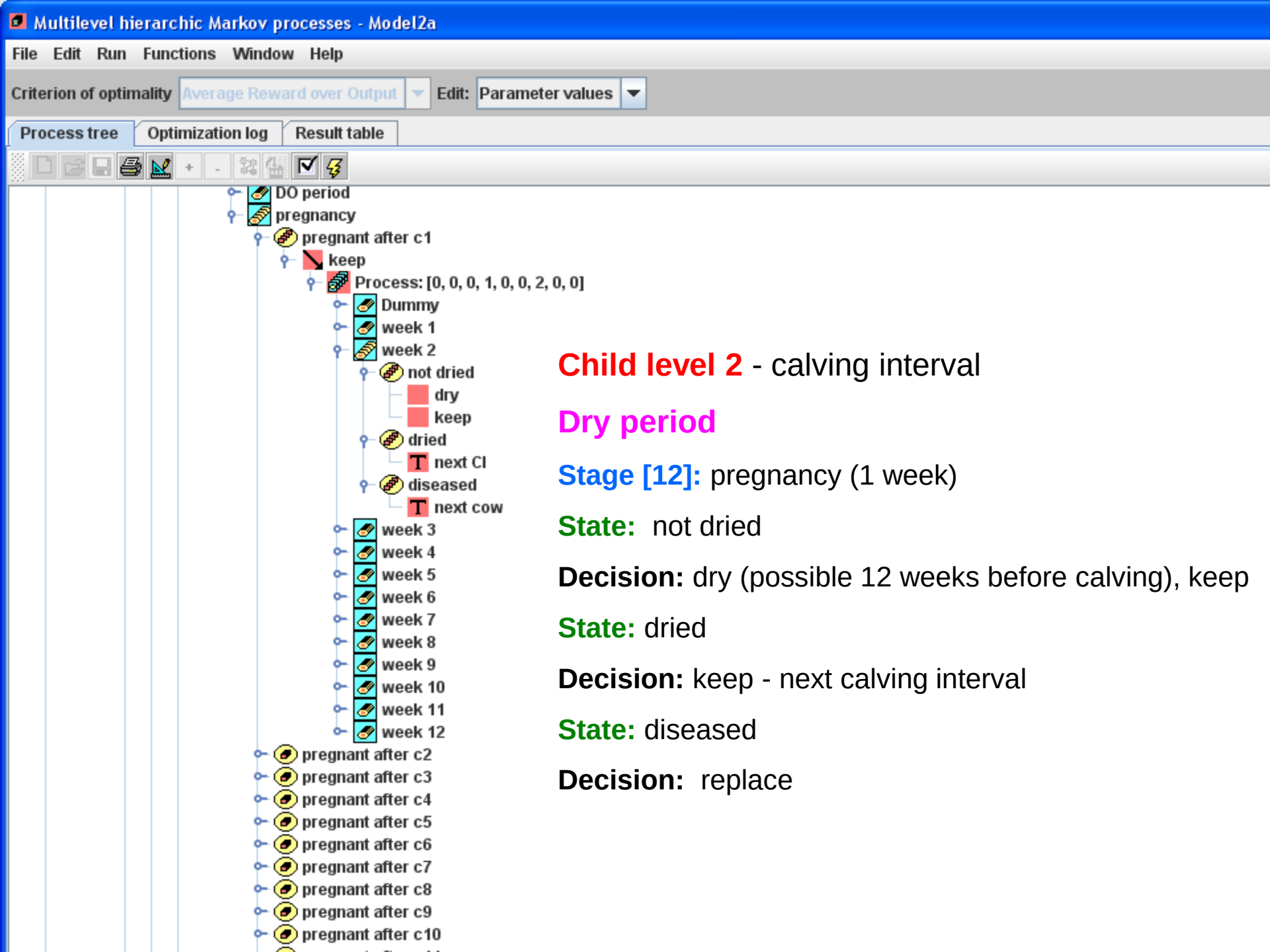
**Decision:** replace after 1, 2, 3 or 4 months

**State:** pregnant

**Decision:** keep - go to **Pregnancy** stage

**State:** diseased

**Decision:** replace


Multilevel hierarchic Markov processes - Model2a
File Edit Run Functions Window Help
Criterion of optimality
Average Reward over Output
Edit:
Parameter values
Process tree
Optimization log
Result table
DO period
pregnancy
pregnant after c1
keep
Process: [0, 0, 0, 1, 0, 0, 2, 0, 0]
Dummy
week 1
week 2
not dried
dry
keep
dried
next CI
diseased
next cow
week 3
week 4
week 5
week 6
week 7
week 8
week 9
week 10
week 11
week 12
pregnant after c2
pregnant after c3
pregnant after c4
pregnant after c5
pregnant after c6
pregnant after c7
pregnant after c8
pregnant after c9
pregnant after c10
Child level 2 - calving interval
Dry period
Stage [12]: pregnancy (1 week)
State: not dried
Decision: dry (possible 12 weeks before calving), keep
State: dried
Decision: keep - next calving interval
State: diseased
Decision: replace

**After the determination of the optimal policy**

**the technical and economic key figures**

**(production and reproduction indices, net returns)**

**characterizing the optimal policy**

**or defined non-optimal policy**

**are calculated by using**

**the probabilistic Markov simulation.**

# Baseline scenario - sensitivity analysis

To examine the impact of alteration in economic and production variables on the optimal policy and to determine the most critical (sensitive) parameters of the model.

The value of objective function and the values of decision variables (e.g. days open length, days dry length) can be observed for:

varied probability of conception,

varied price of milk, carcass and a calf,

varied costs of replacement heifer, feed and insemination

non-optimal days open and days dry length

# Conclusions

**The developed model has the potential:**

**to be successfully used for getting insight into efficiency of dairy cow management**

**to support the optimal decisions in various production conditions**

# Thank you for your attention !