Qualitative modelling and analysis of Photosystem II

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Photosystem II - background, motivation, …
Model development
Qualitative analysis
  • P-invariants
  • T-invariants
  • analysis by CTL model checking
Conclusions
Photosynthesis

Qualitative modelling and analysis of Photosystem II
Photosynthesis

http://www.e-photosynthesis.org

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Qualitative modelling and analysis of Photosystem II
Scheme of electron transitions in photosystem II

Electron transitions

Qualitative modelling and analysis of Photosystem II
Examples of questions to be asked

- Does the behaviour and features of models depend on presence/absence of particular photosystem II subunits?
- Are all the current theories about photosystem II valid?
- Can the model reach some final (stable) state?
- Are there any possible electron cycles which have not yet been observed?
- Are the existing models correct?
Model development

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Created models

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P-invariants

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Qualitative modelling and analysis of Photosystem II
P-invariants

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T-invariants

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"trivial" T-invariants
T-invariants

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Qualitative modelling and analysis of Photosystem II
\( \phi_1 = EG(EF(P \land Q_a \land Q_b) \land \neg(Q_b_{-\text{minus}_2})) \)

\( \phi_2 = AG(P_{+\text{plus}} \rightarrow EF(P)) \)

\( \phi_3 = AG((P \rightarrow AF(P_{+\text{plus}}) \land (P_{+\text{plus}} \rightarrow AF(P))) \)

\( \phi_{4a} = AG((P_{+\text{plus}} \land Q_a \land Q_b) \rightarrow AX((P \land Q_a \land Q_b))) \)

\( \phi_{4b} = AG((P_{+\text{plus}} \land Q_a \land Q_b \land Yd_{+\text{plus}} \land Yz_{+\text{plus}}) \rightarrow AX((P_{+\text{plus}} \land Q_a \land Q_b \land Yd_{+\text{plus}} \land Yz))) \)
Scheme of electron transitions in photosystem II

Electron transitions

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Analysis by CTL

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Analysis by CTL

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Conclusions:

- Example of new approach for modelling photosystem II
- Creation and comparison of different models
- Specification of some important features and their validation by CTL (e.g. reachability of critical state)
- Discussed influence of non-functionality of OEC

Future work:

- Specification and validation of new features
- Extension of models by other protein complexes in the photosynthesis chain
- Validation of obtained information about our models in real system or in existing quantitative models
Thank You for your attention