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



Photosynthesis



http://www.e-photosynthesis.org

Photosystem II



Electron transitions

Scheme of electron transitions in 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



Created models



Created models



P-invariants



P-invariants



P-invariants



T-invariants



"trivial"T-invariants



T-invariants



State space



 $\phi_1 = \textit{EG}(\textit{EF}(\textit{P} \land \textit{Qa} \land \textit{Qb}) \land !(\textit{Qb_minus_2}))$

 $\phi_2 = AG(P_plus \rightarrow EF(P))$

 $\phi_3 = AG((P \rightarrow AF(P_plus) \land (P_plus \rightarrow AF(P))))$

 $\phi_{4a} = AG((P_plus \land Qa \land Qb) \rightarrow AX((P \land Qa \land Qb)))$

 $\phi_{4b} = AG((P_plus \land Qa \land Qb \land Yd_plus \land Yz_plus) \rightarrow AX((P_plus \land Qa \land Qb \land Yd_plus \land Yz)))$

Electron transitions

Scheme of electron transitions in photosystem II











Conclusions and future work

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