The surveillance of animal diseases and the development of epidemiological models

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Surveillance and modeling

- It's common knowledge that modeling takes advantage of data generated by surveillance activities
- Less frequently considered is the reverse: how information generated by modeling can influence surveillance? How modeling results can suggest a modification in the design of surveillance activities?
- Can a model be incorporated in a surveillance system and give real time suggestions on a better targeting of surveillance activities?

Modeling and design of surveillance activities

- Epidemiological surveillance is a costly activity
- Whoever pays for surveillance activities, be it the government or the industry or variable combinations thereof, it will strongly press to reduce costs and to optimize the cost-effectiveness of activities
- The optimization of cost-effectiveness is never a trivial endeavor

Modeling and design of surveillance activities

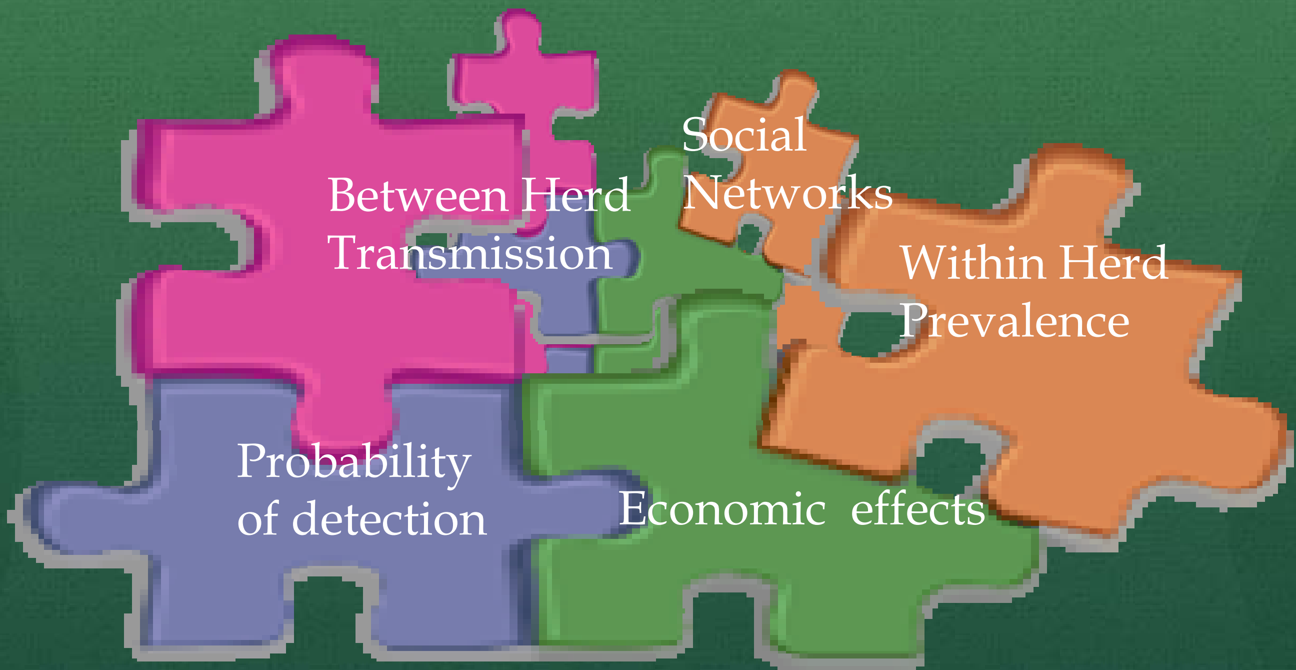
- In many cases, the design of a surveillance system is strictly dependant on the objectives and there is very limited scope for optimization
- This is the case of very severe zoonoses or animal diseases with a heavy economic impact for the industry
- Sometimes the reasons why a disease is considered a priority disease leave very limited scope for optimization and for the use of modeling (e.g. BSE)

Modeling and design of surveillance activities

- In other cases, the planning of a surveillance system can take advantage of the results of simulation models, in relation to the facts that:
  - the behavior of epidemiological systems is never linear or uniform (there are lags in the spread of infections, saturations in the number of cases, clustering, ...) and the doubling of resources allocated to a specific factor almost never produces a doubling of the effectiveness of the system
  - The value of different possible sub-populations in allowing the detection of infection is never uniform
  - The cost of undetected infection in different sub-populations may vary dramatically

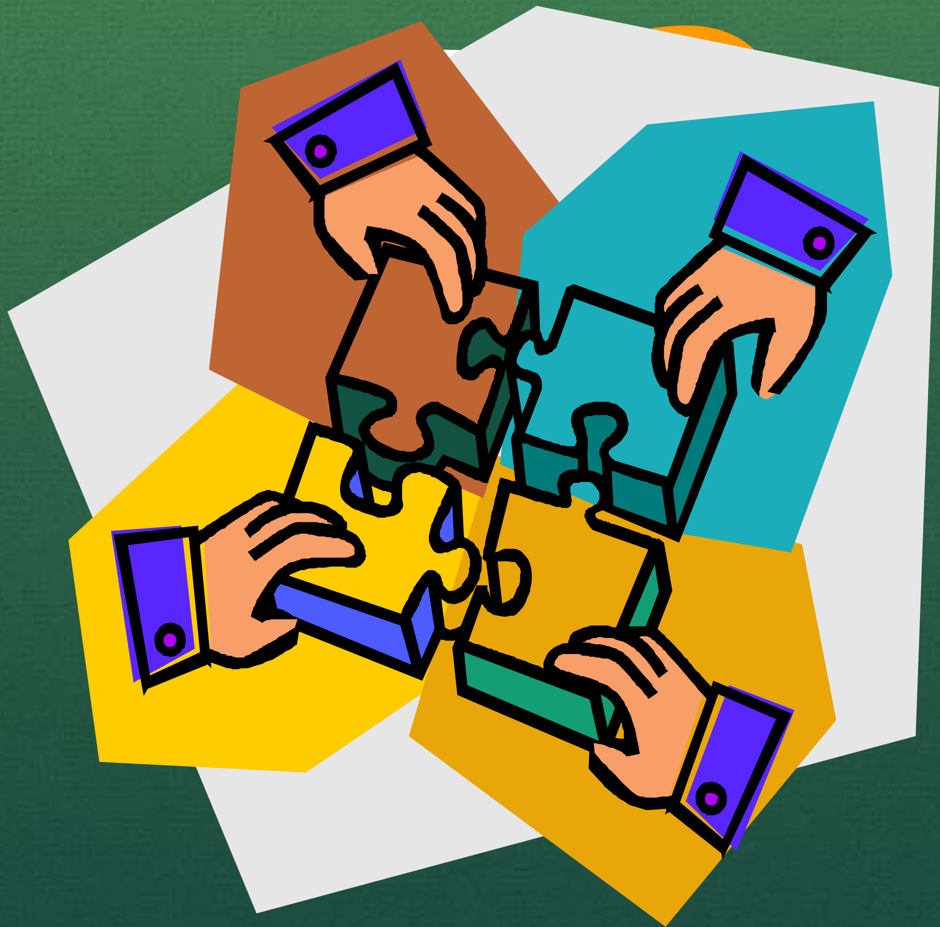
Modeling and design of surveillance activities

Combinations of Models and Methods



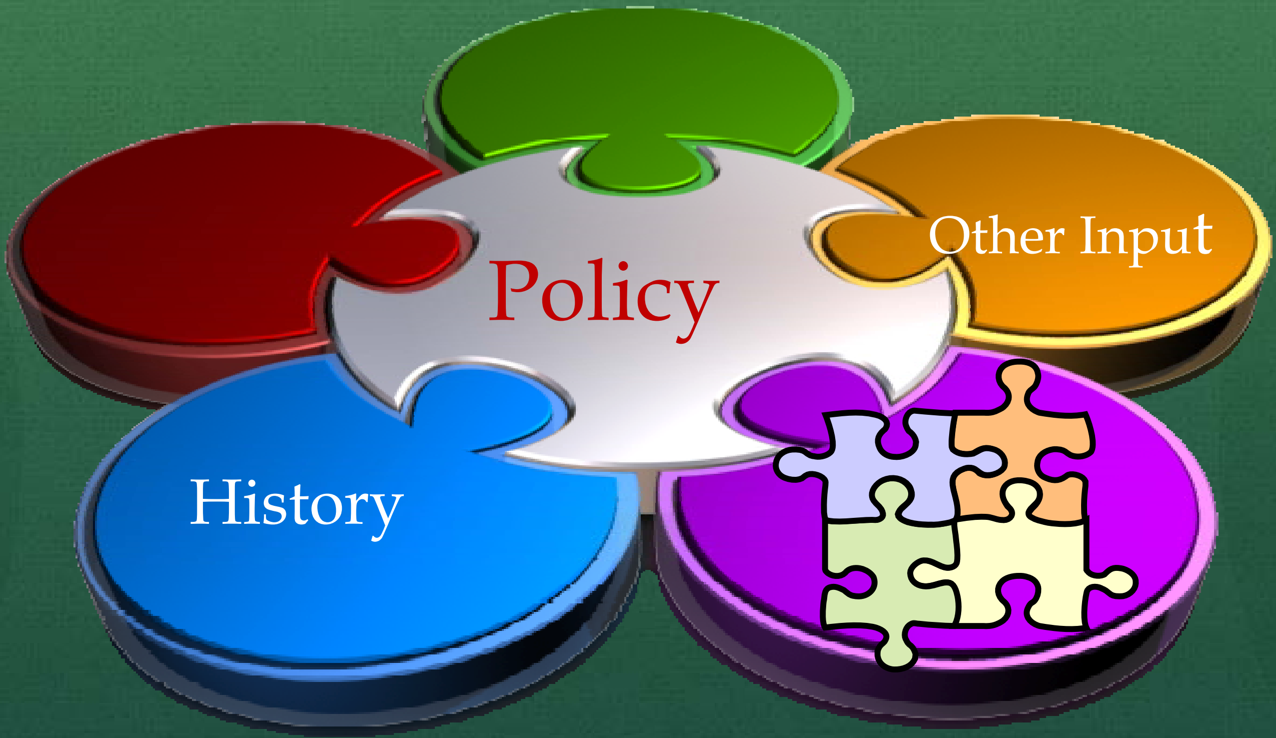
Modeling and design of surveillance activities

Validation and Verification



Modeling and design of surveillance activities

Understanding and incorporating model results



Modeling and design of surveillance activities

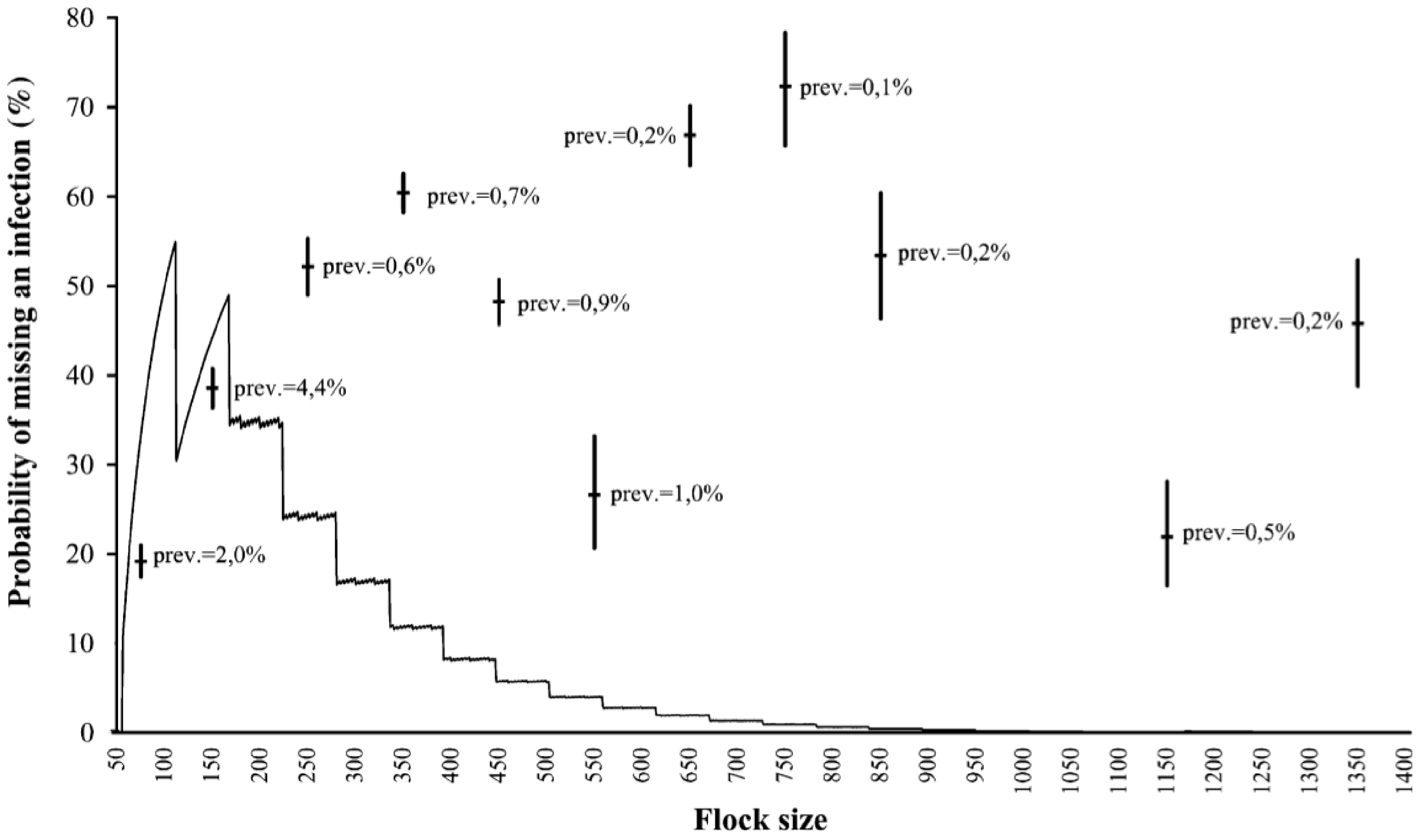
- Detailed examples will be presented tomorrow and next Thursday on the use of modeling in the design and revision of surveillance systems

- In particular, the evaluation of the cost-effectiveness of possibly alternative detection system is a quite straightforward activity; factors that can be compared are:
  - sample sizes at various levels (herd level, within herd level)
  - different tests and combinations of tests

Modeling and design of surveillance activities

- Other factors that can be taken into account by using models are, for example:
  - the fact that infections are to be ideally detected in their initial phase, when the number of cases in a herd is very low; therefore in larger herds the infection should be ideally detected at lower prevalence levels than in smaller herds, which entails a lower effectiveness of detection systems

Results: Theoretical probability (solid line) of missing the flock infection in case of 1.79% within-flock prevalence and results of simulation with 95% CI subdivided by flock-size class



Better targeting of surveillance

- When very detailed information on animal movement exists, methods like the Social Network analysis may give a precise classification of the levels of risk of spread posed by the various herds and holdings belonging to the network
- For example, by analyzing the network of cattle movements in Italy, the following results were obtained

Spread of infection to neighboring nodes

Table 4

Correlation between centrality values of premises and number of times they are responsible for the first infection of neighbouring nodes and time they get infected.

	Degree	Betweenness	Eigenvector	Closeness
No. of times node is responsible of infection	0.98 (out)	0.46	0.52	0.14 (out)
Time of infection	–0.24 (in)	–0.17	–0.42	–0.17 (in)

Simulations are conducted using a meta-population model on the largest strong connected component emerging in the network of cattle movements in Italy in October 2007. Results are averaged over 100 iterations choosing randomly different seeding sites.

Spread of infection throughout the network

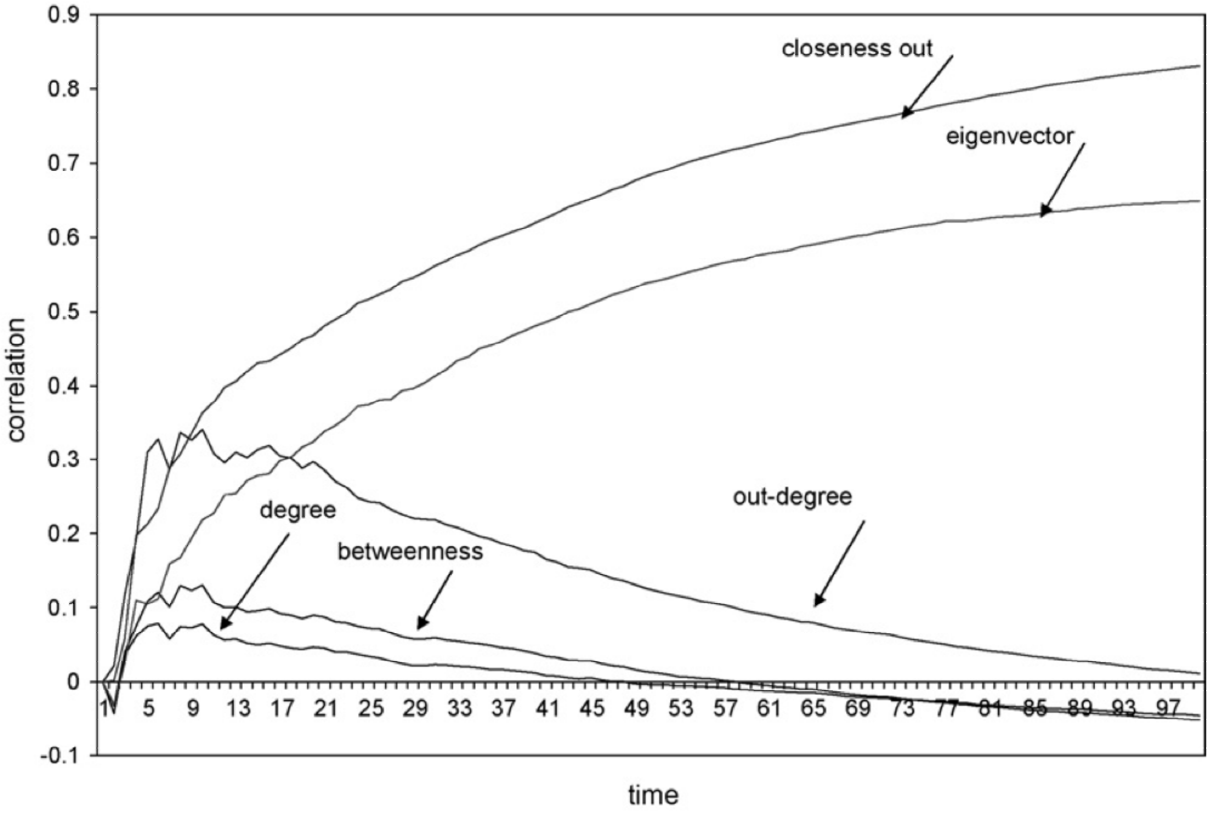
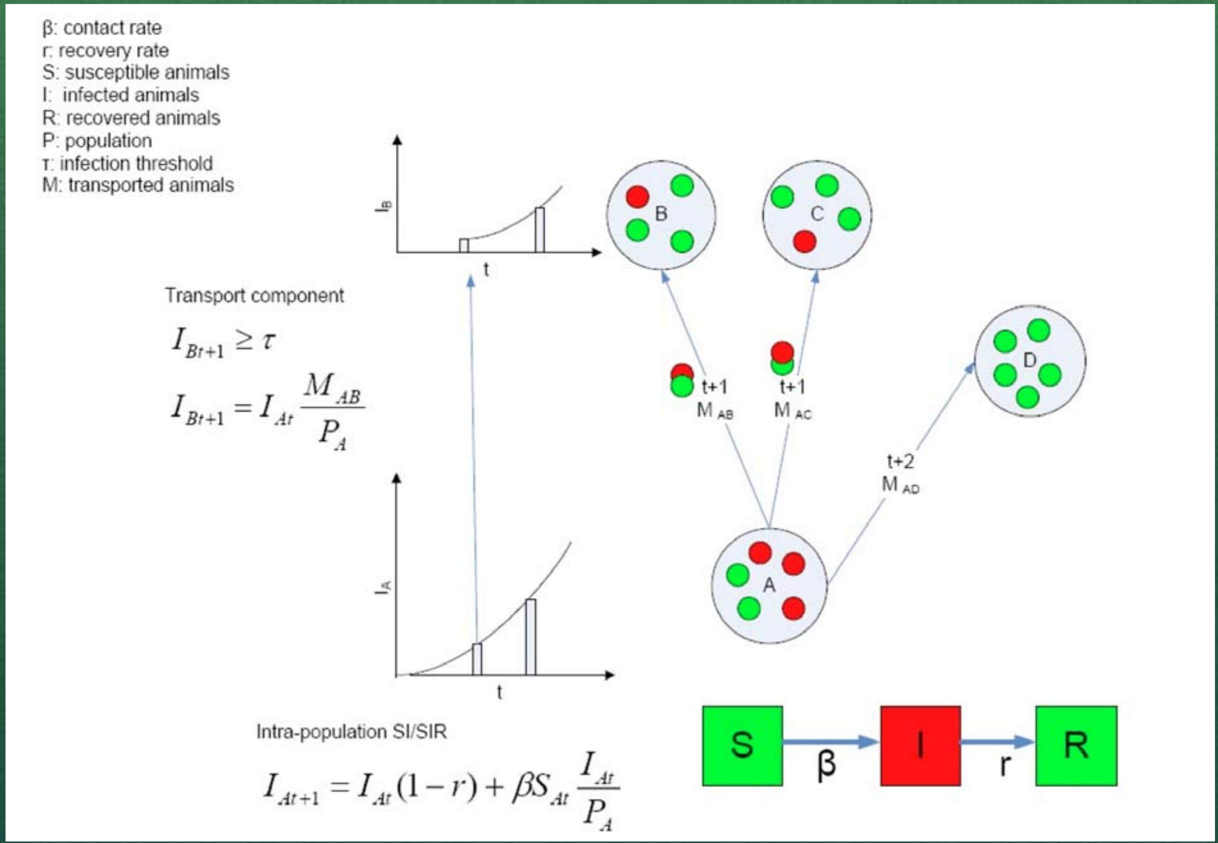


Fig. 5. Correlation between centrality measures of seeding sites and number of infected sites at the different time steps of the simulation. Simulations are conducted using a meta-population model on the largest strong connected component in the network of cattle movements in Italy in October 2007. Results are averaged over 100 iterations choosing randomly different seeding sites.

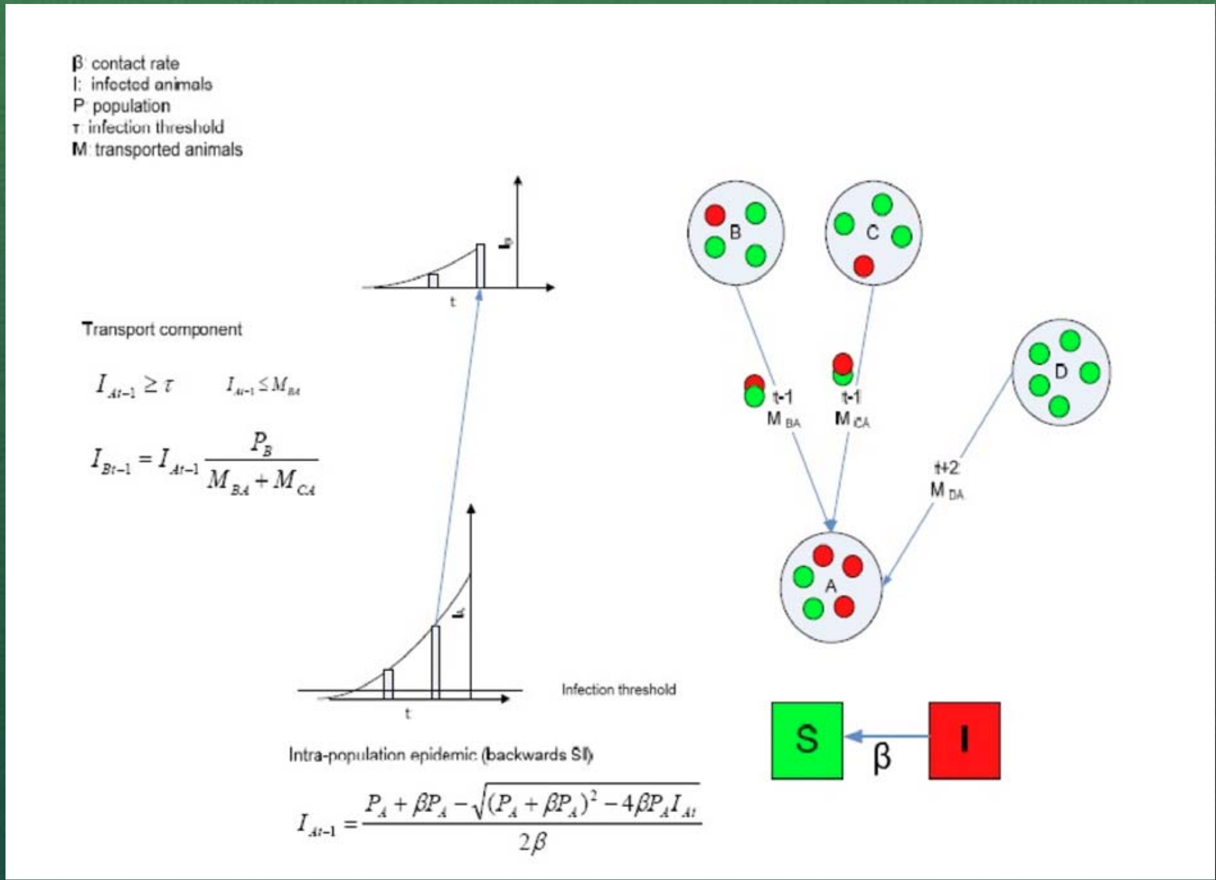
Embedding a model in a surveillance system to get real-time evaluations

- Models can be embedded into a surveillance system to assist veterinary services in the optimization of tracing (back and forth) the spread of infection in case of an epidemic.
- The following example will be discuss during the next days of the workshop.

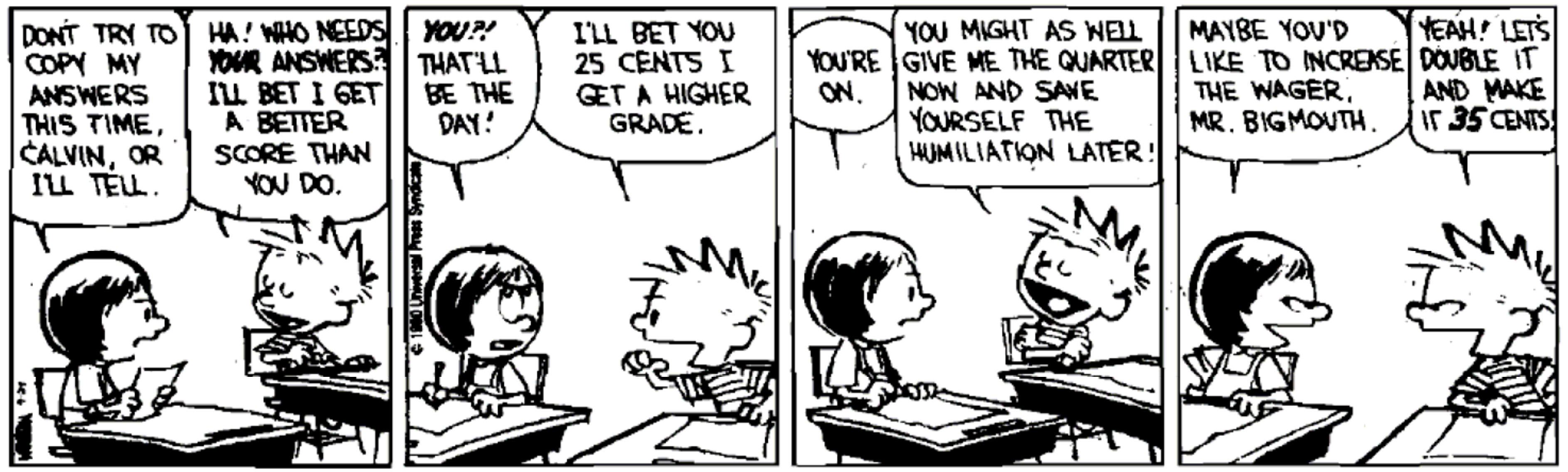
Embedding a model in a surveillance system to get real-time evaluations: trace-forward



Embedding a model in a surveillance system to get real-time evaluations: trace-back



Thank you


DON'T TRY TO COPY MY ANSWERS THIS TIME, CALVIN, OR I'LL TELL.
HA! WHO NEEDS YOUR ANSWERS?! I'LL BET I GET A BETTER SCORE THAN YOU DO.
YOU?! THAT'LL BE THE DAY!
I'LL BET YOU 25 CENTS I GET A HIGHER GRADE.
YOU'RE ON.
YOU MIGHT AS WELL GIVE ME THE QUARTER NOW AND SAVE YOURSELF THE HUMILIATION LATER!
MAYBE YOU'D LIKE TO INCREASE THE WAGER, MR. BIGMOUTH.
YEAH! LET'S DOUBLE IT AND MAKE IT 35 CENTS!