A PhD candidate will explore techniques to infer causal models for networks from single observations. The objective of this project is to develop methods to infer causal models that represent the dependencies between components or nodes of the network, given a set of event logs and possibly sampled KPIs of these components. The vector of event logs can be seen as a single data point, hence in absence of prior knowledge about, e.g., distributions of events, well-known statistical inference approaches are not applicable. The PhD candidate will benefit from a large degree of autonomy regarding the evaluation and interpretation of results as well as the tuning of the algorithm.

**Contexte et atouts du poste**
The work will take place at Inria Univ. Grenoble Alpes, Montbonnot, France either with frequent travels to Nokia Bell Labs, Massy, France.

**Mission confiée**
Context. Networks such as modern telecommunications networks or distributed embedded systems are permanently monitored to allow identification of failure situations; thousands of new data points reflecting the system state changes are generated every minute. Even if faults are rare events, they can easily propagate driven by local and remote dependencies, which makes it challenging to distinguish causes from effects among the thousands of highly correlated alerts. A timely automated identification and root cause analysis (RCA) is a hard problem, because it requires a deep knowledge of causal-effect dependencies among many features, physical and logical components the network nodes. In a data driven approach, where most of this knowledge is unavailable a priori, a major difficulty emanates from hidden or unknown variables. Furthermore, even in a fully observable system we are faced with the combinatorial explosion of potential causal-effect dependencies and the difficulty to collect enough information for distinguishing causality from spurious correlations.

Goals. The objective of this project is to develop techniques to infer a causal model that represents the dependencies between components (or nodes) of the network, given a set of event logs and possibly sampled KPIs of these components. The vector of event logs can be seen as a single data point, hence in absence of prior knowledge - about, e.g., distributions of events -, well-known statistical inference approaches are not applicable. The PhD candidate will benefit from a large degree of autonomy regarding the evaluation and interpretation of results as well as the tuning of the algorithm.

**Principales activités**
Approach. We will explore the use of non-reversibility to infer direction of causation. The rationale is that the complexity of the "true" causal process is expected to be in a lower class than the complexity of reconstructing a cause by only knowing its effect. This principle has been studied in the literature in statistical settings. However, these results have two shortcomings: they require the probability distributions to be known, or are based on Kolmogorov complexity, which is not computable.

1. To apply complexity-based causal discovery to a single observation or when the distribution is complex or unknown, the first goal of the project is therefore to formalize this principle in a deterministic and decidable setting. Similarly, there is an extensive body of work on process discovery from logs [3], which guesses causal dependencies between events. However, this work does not provide any information about causal dependencies on

**Informations générales**
- **Thème/Domaine:** Systèmes embarqués et temps réel
- **Ville:** Grenoble
- **Centre Inria:** Centre Inria de l'Université Grenoble Alpes
- **Date de prise de fonction souhaitée:** 2023-10-01
- **Durée de contrat:** 3 ans
- **Date limite pour postuler:** 2023-08-30

**Contacts**
- **Equipe Inria:** SPADES
- **Directeur de thèse:** Goessler Gregor / gregor.goessler@inria.fr

**A propos d'Inria**
Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 200 équipes-projets agiles, en général communées avec des partenaires académiques, impliquent plus de 3500 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut a accompagné la création de plus de 180 start-up. L'institut s'engage ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

**Consignes pour postuler**
- **Sécurité défense:** Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la sécurité défense.
the level of components.
2. To cope with the complexity of causal discovery, our second goal is to (1) study whether it can be decomposed, in a multi-variable setting, into local analyses like the decomposition into Markov kernels in a statistical setting, and (2) identify tractable complexity classes that match typical behavior of basic network equipment and services.
3. Our third goal of the project is to study applications of the proposed causal inference to the construction of causal explanations for network failures, and/or the detection of change of behavior in terms of altered causal dependencies.

**Compétences**
Candidates should be pursuing internationally recognized research in ML/AI, information theory, or formal methods, with a strong interest in causal inference and causal reasoning.

**Avantages**
- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

**Rémunération**
- 1st Year: 2082 euros gross salary monthly
- 2nd & 3rd Year: 2190 euros gross salary monthly